Compressed Air Magazine

Vol. 41, No. 1 London - New York - Paris January, 1936

THE GROSSGLOCKNER, AUSTRIA

Compressed Air Magazine

JANUARY, 1936

A Monthly Publication Devoted to the Many Fields of Endeavor in which Compressed Air Serves Useful Purposes

FOUNDED 1896

Volume 41

Number 1

EDITORIAL CONTENTS

ADVERTISING INDEX

Business, Editorial and Publication Offices
PHILLIPSBURG, N. J.

Advertising Office
11 Broadway
NEW YORK CITY

Annual subscription rate: Domestic, $3.00; foreign, $3.50. Single copies, 35 cents.

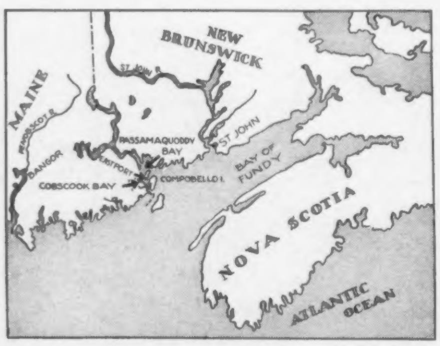
Manuscripts intended for editorial consideration should be accompanied by return postage.

COMPRESSED AIR MAGAZINE is on file in many public libraries and is indexed in INDUSTRIAL ARTS INDEX

RANGE OF TIDE AT EASTPORT

The picture above was taken at 12:19 o'clock on the afternoon of August 16, 1935: the one on the opposite page at 7:05 in the evening of the same day. The average tidal range is 18.1 feet; but on October 13, 1935, it reached a record high of 28.8 feet. To collect data, the Coast and Geodetic Survey has maintained a tide gauge at Eastport since 1929.

ONE of the most fascinating engineering adventures of all time is being embarked upon at Eastport, Me., the easternmost community in the United States. It marks the first large-scale attempt to convert the eternal power of the tides into electrical energy. For centuries the rush of the recurring tides has been made to operate machinery intermittently, and for a good many years men have toyed with the idea of obtaining continual operation, but never before has such a scheme reached the actual construction stage. The undertaking now being launched is designated officially as the Passamaquoddy Tidal Power Development. Unofficially, it goes under the name of the Quoddy Project. It is being directed by the Corps of Engineers, United States Army, and is being financed by the Federal Public Works Administration through allotments from the $4,000,000,000 fund created on April 8, 1935.



LOCATION MAP

Passamaquoddy Bay opens out from the lower part of the Bay of Fundy, famed for its great tidal range, and Cobscook Bay, in turn, from Passamaquoddy Bay.

Streams, tides, and wind are the three natural potential sources of power. The first and last named have been well developed, but relatively little has been done towards harnessing tidal energy. In Great Britain (as remotely as the eleventh century), along the shores of New England, and along the coast lines of South America and other continents, tide mills have been used in past generations to grind grain. Some of them are still in service, and while their efficiency is low their operating costs are trifling.

The usual method of constructing such power plants was to create an inshore reservoir, fill it at high tide, and then allow the water to run back to the sea at low tide through a race in which the water wheel was set up. The well-defined remains of such an installation are still to be seen in Brooklyn, N. Y., within sight of great, modern steam-generating stations which now supply New York City and vicinity with power. Sometimes, through the medium of reversible gear, the plants were arranged to take advantage of both the incoming and outgoing tides, thereby increasing the daily period of operation.

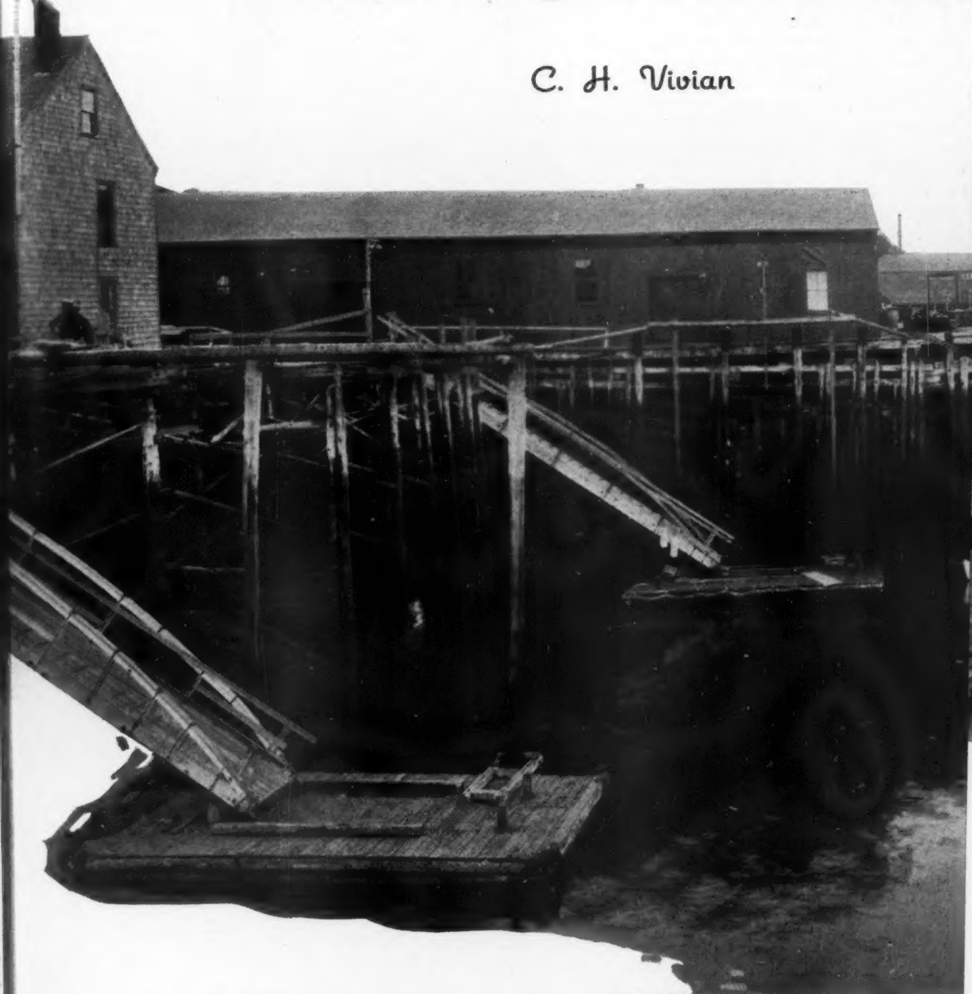
On the Tsientang River, in China, the tides are made to perform another kind of useful work. In this and certain other parts of the world, where rising tides enter narrowing channels, the water builds up into a cascading wave that rushes inland with great force. This phenomenon is known as a bore. The bore on the Tsientang River occasionally reaches 10 feet high. To take advantage of it, Chinese junk men have built jetties out from the river banks, pointing them upstream at a slight angle. Their junks lie in the lee of these obstructions until the bore sweeps them upstream, sometimes at a speed of as much as 10 knots.

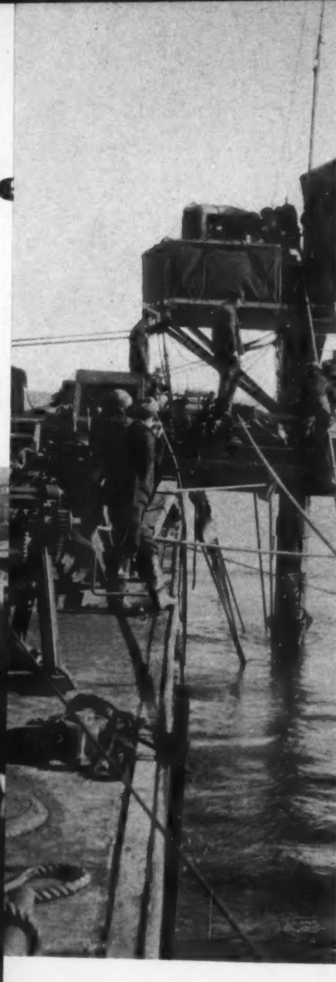
There have been two principal obstacles in the past to the development of tidal power. First, and least important, was the fact that the old-style mill wheels would not work when submerged. However, the modern reaction-type turbine is designed to operate underwater. Theoretically, wherever there is a 6-foot tide, a submerged turbine, using 2,000 cubic feet of water per minute under an average head of 3 feet, will produce 11 hp. A greater stumbling block has been the nature of the tides themselves.

As is well known, tides are primarily the result of the gravitational pull of the moon. The tidal cycle therefore conforms to the lunar and not to the solar day. During the period required by the moon to make its apparent revolution of the earth, the tide advances and recedes twice. The length of the lunar day is 24 hours, 50 minutes, and 14 seconds. Accordingly, on each solar day the high or the low tide comes 50 minutes and 14 seconds later than it did on the preceding solar day.

Power from the Tid

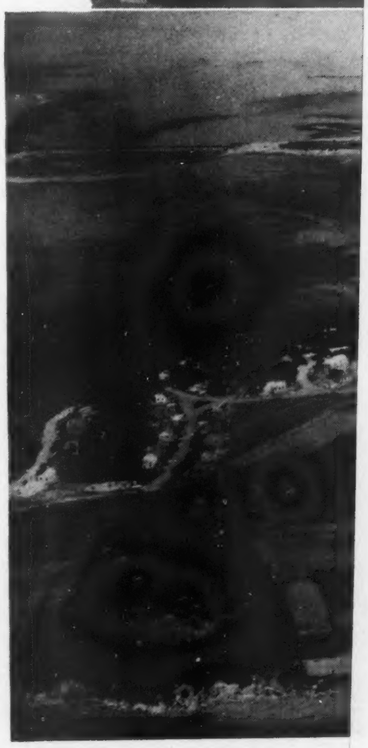
C. H. Vivian





In using tides for generating power there has always been an obvious disadvantage, namely, the time gap between tides when the generators would have to be shut down. While it is essential for general service to have electricity available continuously, it has often been suggested that industrial plants could utilize tidal power on an intermittent basis, just as did the tide mills for grinding grain. The objection to this lies in the difference between the solar day and the lunar day, as just mentioned. Workers in such a plant would have to begin their shift 50 minutes later each successive day. The difficulty of ordering their lives to such a changing schedule has been considered too great to make such a scheme feasible.

Therefore, in order to secure a workable tidal-power plan, it has been realized that means must be provided for producing power continuously, and that is what will be done at Passamaquoddy. The scheme to be followed is a variation of the original one for such projects advanced by M. Decoeur, a French engineer, in 1905. His plan was to make use of two land-locked pools with a power plant as the connecting link between them and each connected separately with the ocean—one to be called the high-level pool, the other the low-level pool. During high or flow tide, gates were



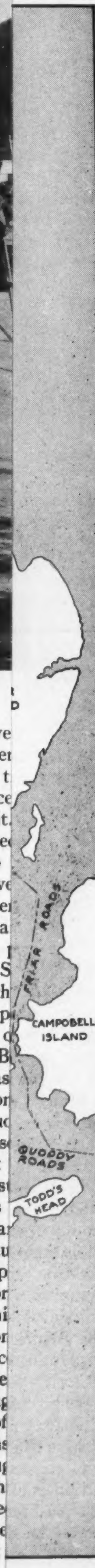
WHERE Q

Aerial view of the site of the r
tive, office, and engineering fo
ings are located in the woode

to be opened betwe
high-level pool, ther
During low or ebb t
low pool and the oce
thereby emptying it.
level or head betwe
level pools was to
times, and the powe
interconnection oper

Examination of a
will show that the p
the tip end of the S
vorable to such a sch
dams, it would be p
rate, adjacent pools o
Bay and Cobscook B
the original idea, as
P. Cooper, to whor
revert. Passamaquo
of the two, was to s
pool, and Cobscook
pool. This plan is s
summation requires
Canada, since Passa
her territory. Eventu
called international p
Meanwhile, work is pr
scale plan which, whi
samaquoddy developr
to neighboring Cobsc

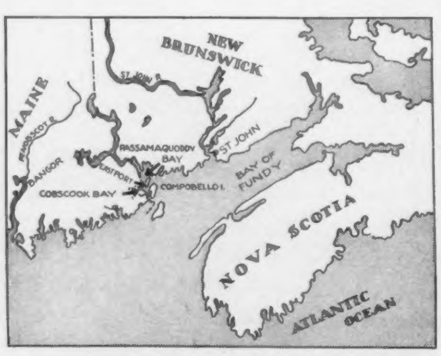
In essence, the sche
Cobscook Bay, having
miles, will be closed of
dy Bay by five dams
contain gates throu
Bay will be filled at h
the gates will be close
at high level. As the
will be brought about



RANGE OF TIDE AT EASTPORT

The picture above was taken at 12:19 o'clock on the afternoon of August 16, 1935: the one on the opposite page at 7:05 in the evening of the same day. The average tidal range is 18.1 feet; but on October 13, 1935, it reached a record high of 28.8 feet. To collect data, the Coast and Geodetic Survey has maintained a tide gauge at Eastport since 1929.

ONE of the most fascinating engineering adventures of all time is being embarked upon at Eastport, Me., the easternmost community in the United States. It marks the first large-scale attempt to convert the eternal power of the tides into electrical energy. For centuries the rush of the recurring tides has been made to operate machinery intermittently, and for a good many years men have toyed with the idea of obtaining continual operation, but never before has such a scheme reached the actual construction stage. The undertaking now being launched is designated officially as the Passamaquoddy Tidal Power Development. Unofficially, it goes under the name of the Quoddy Project. It is being directed by the Corps of Engineers, United States Army, and is being financed by the Federal Public Works Administration through allotments from the $4,000,000,000 fund created on April 8, 1935.



LOCATION MAP

Passamaquoddy Bay opens out from the lower part of the Bay of Fundy, famed for its great tidal range, and Cobscook Bay, in turn, from Passamaquoddy Bay.

Streams, tides, and wind are the three natural potential sources of power. The first and last named have been well developed, but relatively little has been done towards harnessing tidal energy. In Great Britain (as remotely as the eleventh century), along the shores of New England, and along the coast lines of South America and other continents, tide mills have been used in past generations to grind grain. Some of them are still in service, and while their efficiency is low their operating costs are trifling.

The usual method of constructing such power plants was to create an inshore reservoir, fill it at high tide, and then allow the water to run back to the sea at low tide through a race in which the water wheel was set up. The well-defined remains of such an installation are still to be seen in Brooklyn, N. Y., within sight of great, modern steam-generating stations which now supply New York City and vicinity with power. Sometimes, through the medium of reversible gear, the plants were arranged to take advantage of both the incoming and outgoing tides, thereby increasing the daily period of operation.

On the Tsientang River, in China, the tides are made to perform another kind of useful work. In this and certain other parts of the world, where rising tides enter narrowing channels, the water builds up into a cascading wave that rushes inland with great force. This phenomenon is known as a bore. The bore on the Tsientang River occasionally reaches 10 feet high. To take advantage of it, Chinese junk men have built jetties out from the river banks, pointing them upstream at a slight angle. Their junks lie in the lee of these obstructions until the bore sweeps them upstream, sometimes at a speed of as much as 10 knots.

There have been two principal obstacles in the past to the development of tidal power. First, and least important, was the fact that the old-style mill wheels would not work when submerged. However, the modern reaction-type turbine is designed to operate underwater. Theoretically, wherever there is a 6-foot tide, a submerged turbine, using 2,000 cubic feet of water per minute under an average head of 3 feet, will produce 11 hp. A greater stumbling block has been the nature of the tides themselves.

As is well known, tides are primarily the result of the gravitational pull of the moon. The tidal cycle therefore conforms to the lunar and not to the solar day. During the period required by the moon to make its apparent revolution of the earth, the tide advances and recedes twice. The length of the lunar day is 24 hours, 50 minutes, and 14 seconds. Accordingly, on each solar day the high or the low tide comes 50 minutes and 14 seconds later than it did on the preceding solar day.

Power from the Tides

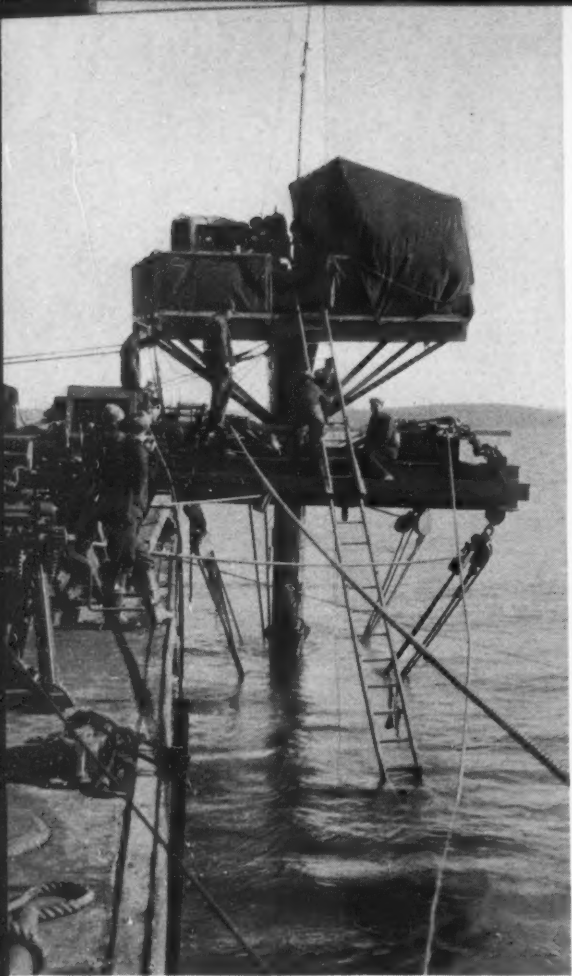
C. H. Vivian

In using tides for generating power there has always been an obvious disadvantage, namely, the time gap between tides when the generators would have to be shut down. While it is essential for general service to have electricity available continuously, it has often been suggested that industrial plants could utilize tidal power on an intermittent basis, just as did the tide mills for grinding grain. The objection to this lies in the difference between the solar day and the lunar day, as just mentioned. Workers in such a plant would have to begin their shift 50 minutes later each successive day. The difficulty of ordering their lives to such a changing schedule has been considered too great to make such a scheme feasible.

Therefore, in order to secure a workable tidal-power plan, it has been realized that means must be provided for producing power continuously, and that is what will be done at Passamaquoddy. The scheme to be followed is a variation of the original one for such projects advanced by M. Decoeur, a French engineer, in 1905. His plan was to make use of two land-locked pools with a power plant as the connecting link between them and each connected separately with the ocean—one to be called the high-level pool, the other the low-level pool. During high or flow tide, gates were

WHERE QUODDY VILLAGE IS RISING

Aerial view of the site of the modern town which will be occupied by the administrative, office, and engineering forces during the construction period. Many of the buildings are located in the wooded area and therefore hidden from view.



SAMPLING THE BOTTOM

The water at the site of the Eastport Dam is 140 feet deep in places, and at that of the Lubec Dam it reaches 90 feet. In both cases there is a layer of mud at the bottom that attains a maximum depth of 90 feet. Test corings along the lines of both these dams are being taken by the Government, which has leased two boats, the *Eastern Chief* and the *Eureka*, for the purpose.

Special equipment has been designed and installed for these operations, which are being carried on under conditions that are said to be unprecedented. The tide runs at velocities up to 8 knots, and it is sometimes necessary to use as many as six anchors to keep a boat stationary.

The pictures show the core-boring equipment at high tide and at low tide. The core barrel, or spud, through which the work is done, consists of 155 feet of 21½-inch pipe having walls ⅞-inch thick. Inside this is a 6-inch casing which is forced into the mud at the bottom by means of tackle. The core is raised with compressed air; and samples taken at 5-foot intervals are sealed in a tube with paraffin and sent to the soils-testing laboratory for analysis.

When rock is reached, a 3-inch casing is run inside the 6-inch one for the extraction of a 1⅛-inch core by a diamond drill. In the deeper water the over-all penetration of water, mud, and rock exceeds 200 feet.

to be opened between the ocean and the high-level pool, thereby filling the latter. During low or ebb tide, gates between the low pool and the ocean were to be opened, thereby emptying it. Thus a difference in level or head between the high- and low-level pools was to be maintained at all times, and the power plant forming their interconnection operated continuously.

Examination of an accompanying map will show that the physical conditions at the tip end of the State of Maine are favorable to such a scheme. By constructing dams, it would be possible to make separate, adjacent pools out of Passamaquoddy Bay and Cobscook Bay. This, in fact, was the original idea, as proposed by Dexter P. Cooper, to whom we shall presently revert. Passamaquoddy Bay, the larger of the two, was to serve as the high-level pool, and Cobscook Bay as the low-level pool. This plan is still alive, but its consummation requires the participation of Canada, since Passamaquoddy Bay is in her territory. Eventually, this broader, so-called international plan, may be adopted. Meanwhile, work is proceeding on a smaller-scale plan which, while known as the Passamaquoddy development, will be confined to neighboring Cobscook Bay.

In essence, the scheme will be as follows: Cobscook Bay, having an area of 46 square miles, will be closed off from Passamaquoddy Bay by five dams. One of these will contain gates through which Cobscook Bay will be filled at high tide. That done, the gates will be closed to retain the water at high level. As the tide goes out there will be brought about a difference in elevation between Cobscook Bay and Passamaquoddy. When that difference reaches 5½ feet, impounded water will be allowed to flow through the turbines of a power house to be erected between the two bays. As shown by an accompanying diagram, it will be possible to generate power continuously for 7 hours and 2 minutes, but between such periods of generation there will be an interval of 5 hours and 23 minutes. To fill in this gap, some of the power will be used to pump water to a high-level reservoir, and this water will be released through the turbines of a second generating station while the main station is idle.

The Passamaquoddy area is especially well suited to such a tidal-power plan, both because it experiences unusually high tides and because the physical characteristics are favorable to the erection of the required structures. The tidal range—that is, the difference in the elevation of the sea between high and low tides—averages 18.1 feet. Computations by the United States Coast and Geodetic Survey, which are based partly on actual investigations and partly on theoretical calculations from general data, indicate that the lowest range that may be expected is about 9 feet, and the highest about 26 feet. (On October 13, 1935, the range was 28.8 feet, the highest on record since observations have been taken.) Passamaquoddy Bay opens off the lower part of the Bay of Fundy, which has long been known for its vast tidal range. The Bay of Fundy is 148 miles long, and tapers from a width of 48 miles at its mouth to virtually nothing at its head. The consequent confining of the flow in a continually contracting channel gives rise to a tidal range that sometimes reaches 62 feet at the head of the bay.

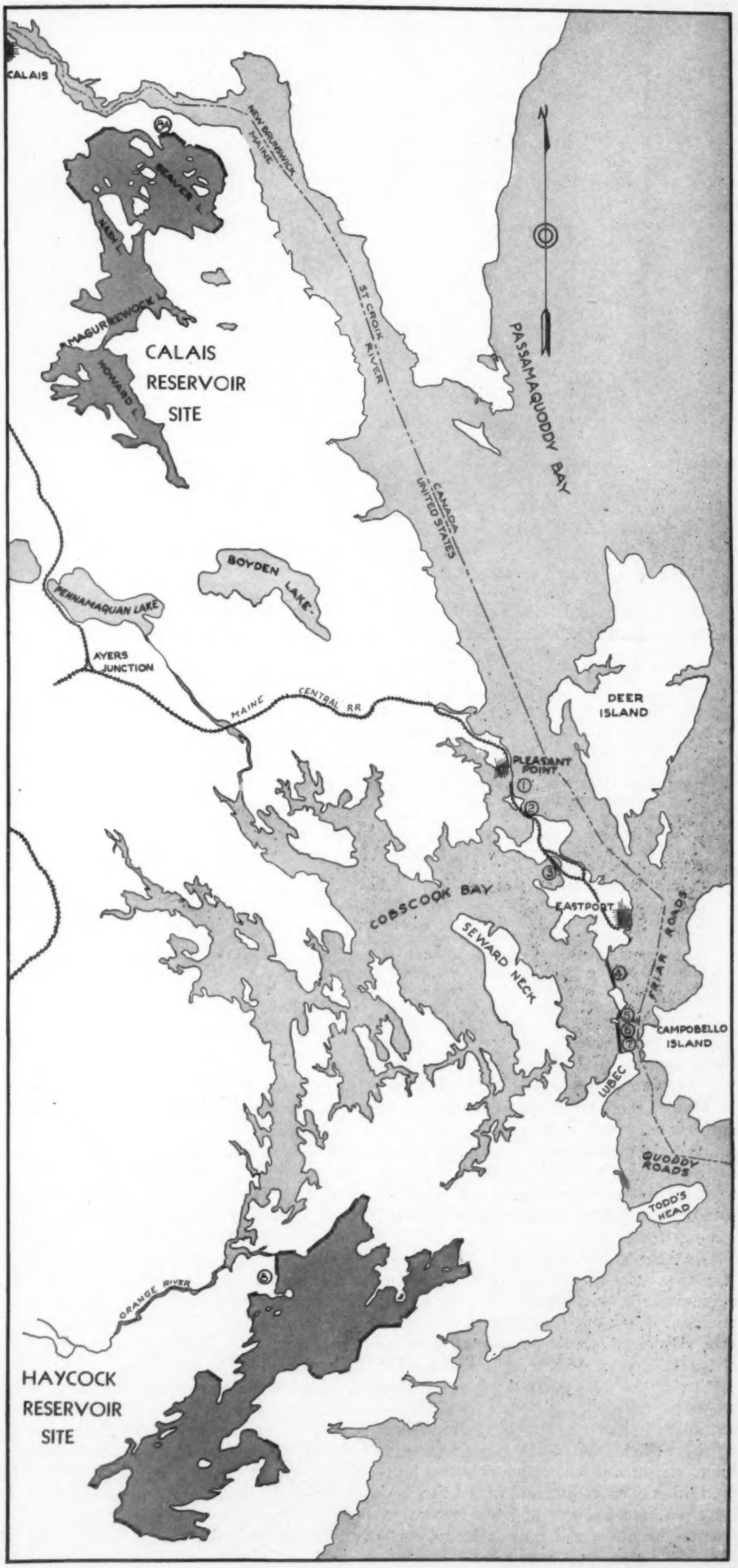
The possibilities of harnessing the tides in this area were first given serious consideration by Dexter P. Cooper, whom we have mentioned previously. Mr. Cooper is a brother of Hugh L. Cooper, one of the world's foremost hydro-electric engineers, and, like the latter, has been identified with power-development work for many years. In 1919 he went to Campobello Island in Passamaquoddy Bay to recuperate from an illness. Day after day he watched the tremendous tides sweeping in from the sea and rushing back a few hours later. The enormous potentialities of the power they harbored were immediately apparent to him, and he became interested in seeking means to put that energy to practical use. He organized the Dexter P. Cooper Company and conducted surveys and investigations. Sufficient money to do all that he wanted to do was not readily obtainable, but he continued to amass data. He worked out several plans of possible procedure, and sought to interest private capital in their development; but the amount of money required was so great, and the indicated cost of producing power was so high, that he was unsuccessful. Nevertheless, he kept at it. He spent most of his time in the area, and built a home on Campobello Island, Canada, just across a short stretch of water from Eastport.

Adjoining Mr. Cooper's residence is the summer home of President Franklin D. Roosevelt, who was likewise impelled to seek the invigorating air of this section

because of ill health. In the years before his public duties became so pressing, Mr. Roosevelt visited Campobello periodically, and it was only natural that he should become acquainted with Mr. Cooper's scheme and in time have more than a passing interest in the possibility of converting the force of those amazing tides into electrical energy. Thus it happened that when the Federal Government was seeking public projects that would take people off the relief rolls, the Passamaquoddy plan had a friend at court, so to speak. It was approved early last spring, and within a few weeks the U. S. Army Engineers were on the ground. The undertaking was formally dedicated on July 4, when Vice President Garner pressed a key in Washington that detonated the first blast.

When the Government took over the development, Mr. Cooper made available to its engineers all the data he had collected, as well as certain rights, privileges, and franchises that had been granted to him or to his company. In return for these services, the War Department last October agreed to pay Mr. Cooper $60,000.

There has been much discussion and not a little controversy over the economical justification of the project. Critics have held that the cost of developing power will be excessive; that there is no need for more power in Maine; and that the rights of private power companies will be encroached upon. To all this, those that are directing the work reply with disarming and reassuring frankness. While they will not officially give the estimated cost of generating power, they freely admit that it will be higher than the general average throughout



MAP OF PROJECT

The line of structures at the right will make Cobscook Bay a placid, landlocked pool and one of the finest of harbors. The heavily shaded areas at the top and bottom are the storage reservoir sites which are now being examined to determine which shall be used. The Haycock site (No. 8), which was first considered, would provide a storage basin for 130,000 acre-feet Its high-water elevation would be approximately 120 feet, and its area at that level 8,170 acres. The Calais site (No. 8-A), where several lakes now exist, is at elevation approximately 200. It would permit building a reservoir of some 5,000 to 6,000 acres in extent; it would require less land clearing than the Haycock site; and preliminary investigations indicate that better foundations would be available there for the necessary retaining dikes. It is expected that a considerable proportion of the labor force will be kept busy clearing the reservoir site during the present winter. A transmission line will connect the main and auxiliary power houses. Todd's Head, just below Campobello Island, is the easternmost point of land in the United States. Incidentally, the line of structures along the coast will serve to connect insular Eastport with Lubec, on the mainland. Boats now are the only direct means of communication. Further descriptions of the line of numbered structures are given at the top of the following page.

KEY TO CONSTRUCTION

Shown here are the locations of the structures which will make a pool of Cobscook Bay. The Government will construct items 4 and 7, which are both large dams. The other items will be built under contracts, of which there may be as many as five, but the Government will furnish all cement, sand, gravel, granite facing, and large-dimension stone which they may require. The following tabulation identifies each structure by number, and gives the quantities of the principal materials that will have to be handled in building it.

(1) Pleasant Point Dam. Length, 2,700 feet; height, 33 feet. Rock fill, 78,000 cubic yards; earth fill, 38,000 cubic yards; riprap, 15,000 cubic yards.

(2) Carlow Island Dam. Length, 1,500 feet; height, 33 feet. Rock fill, 65,000 cubic yards; earth fill, 24,000 cubic yards; riprap, 7,000 cubic yards.

(3) Power house—10 units, 80-foot spacing. Dredging, 7,530,000 cubic yards; earth excavation, 740,000 cubic yards; rock excavation, 320,000 cubic yards; earth fill, 170,000 cubic yards; granite facing, 75,000 cubic feet; concrete, 250,000 cubic yards.

(4) Eastport Dam. Length, 3,400 feet; height, 140 feet. Rock fill, 2,100,000 cubic yards; earth blanket, 1,700,000 cubic yards; riprap, 80,000 cubic yards.

(5) Filling-gate structure—25 gates each 30x30 feet. Dredging, 900,000 cubic yards; rock for cofferdam, 650,000 cubic yards; rock excavation, 730,000 cubic yards; rock fill, 25,000 cubic yards; concrete, 85,000 cubic yards.

(6) Navigation lock on Dudley Island—56x350 feet, 30-foot draft. Rock for cofferdam, 40,000 cubic yards; rock excavation, 110,000 cubic yards; earth excavation, 26,000 cubic yards; rock fill, 47,000 cubic yards; earth fill, 14,000 cubic yards; granite facing, 95,000 cubic yards; concrete, 20,000 cubic yards.

(7) Lubec Dam. Length, 3,800 feet; height, 90 feet. Rock fill, 1,660,000 cubic yards; riprap, 90,000 cubic yards; earth blanket, 850,000 cubic yards.

The construction of the pumped storage reservoir and power house will also be by contract. Quantities for the Calais site have not yet been determined. Those for the Haycock site are: Earth and rock fill, 3,700,000 cubic yards; earth and loose-rock excavation, 100,000 cubic yards; rock excavation, 370,000 cubic yards; riprap, 120,000 cubic yards; granite facing, 46,000 cubic feet; concrete, 200,000 cubic yards.

the country. As to the need for more power in Maine, they acknowledge that it does not now exist; but they point out that it is proposed to attract industries to the region to absorb it. Mr. Cooper has been assigned to direct this movement, and it is officially stated that he is already meeting with some success.

The magnet in this respect is the scenery of Maine, its summer climate, and the opportunity the state offers to locate industrial developments away from congested urban districts. A part of the plan includes the setting up of the Passamaquoddy Authority for the purpose of developing wharves, utilities, and other services essential to industry. It should be pointed out here that Cobscook Bay will become a huge land-locked harbor with several hundred miles of shore line and with a range of less than 3 feet between high and low water. One of the dams will have a lock of sufficient size to accommodate large vessels.

In answer to the third criticism, assurance is given that the Government has no intention of entering into competition with the established private power companies. The area is now served by the Bangor Hydro-Electric Company, but only 2 per cent of its load is delivered east of Machias. As the Government does not expect Quoddy power to be transmitted much farther west than Machias, the existing company does not stand to lose much business. Moreover, it is intended to restrict the distribution of Quoddy power to industries, leaving the domestic field to the private concerns. As an influx of people, attracted by new industries, would swell the business of the Bangor Hydro-Electric Company, it is officially stated that that concern is in favor of the development. Incidentally, it will be necessary for the State of Maine to create an authority for the actual sale of the power, as this is not within the constitutional province of the Federal Government. Legislation to that end is expected to be enacted soon.

While detailed plans have not yet been prepared, it is estimated that the undertaking will cost somewhere in the neighborhood of $41,000,000, exclusive of engineering costs. Whether or not the rates which will be charged for power will provide for the amortization of this capital charge, that is something for the future to determine; but the general impression is that they will not. In other words, it will probably be the policy to set the rates low enough to induce industries to locate in the area, and these rates may or may not cover more than the operating costs. The contention of the Government in this respect is that the project represents a great effort in a new field of hydraulic engineering. As such, it holds that the expenditure of public

money is justified, particularly as the work is being done primarily with labor taken from the relief rolls. It is pointed out that it is within the Government's province to further research of this kind; and that it has been demonstrated in the past that private capital could not be persuaded to do it. It is entirely possible, so it is asserted, that Passamaquoddy may prove to be a laboratory that will enable us to learn how to harness the tides effectually and economically, and that it may, in consequence, be the forerunner of similar extensive developments. All in all, it is felt that the public attitude towards the Passamaquoddy venture should be akin to that shown such works as the Mississippi River improvements, where millions of dollars are being spent for the common good without any severe adverse criticism.

The original allotment of funds for Passamaquoddy was $10,000,000. This was later cut to $5,000,000, but $7,000,000 was subsequently added. The total sum appropriated to date is, accordingly, $12,000,000. Up to the middle of November, commitments aggregating $2,641,000 had been made.

Eastport and its environs hum with activity as some 5,000 persons busy themselves with the multiplicity of tasks that are essential to get such a huge construction job underway. In a manner of speaking, the stage is now being set or, more accurately, being built, for other than the natural setting there was little else available when the first forces moved in last June. Complete housing accommodations for the workers had to be provided, as well as facilities for carrying out the thousand-and-one operations that will enter into the job. Moreover, only a general idea of the engineering procedure that was to be followed existed at the outset.

There were three plans under advisement. Each had to be investigated, its advantages and disadvantages appraised, and its probable costs determined and reported upon in order that an intelligent choice might be made. With a view to preventing a time lag between the planning and construction periods, other investigations had to be conducted to determine the most effective means of building the various structures which the project called for.

With these manifold efforts going on simultaneously, it was inevitable that some confusion should result, particularly as it was highly desirable to get things in order before the rigorous and uncompromising Maine winter laid its icy hands upon the landscape. Fortunately, and to the credit of those in charge, it can be reported that within the short span of six months most of the essential preliminaries were finished and the way cleared for starting construction in the spring. Meanwhile, there is work laid out for the winter—work of a kind that can be carried on in spite of the threat of the traditionally severe weather that prevails there during that season.

At the head of the organization is Lieut. Col. Philip B. Fleming, who serves as district engineer and who also holds the post of PWA Administrator for Maine. Under him are four army officers, each of whom heads one of the four major departments. These men and the activities they direct are: Capt. Hugh J. Casey, engineering; Capt. R. B. Lord, operations; Capt. Donald Leehey, administration; and Capt. Samuel B. Sturgis, land acquisition and housing administration. The engineering department is charged with the responsibility of making the necessary investigations and researches and of designing the various required structures. To facilitate these phases of the operations, it has set up three divisions, each of which has jurisdiction over specific parts of the work involved. A group of prominent engineers is assisting the Government in the capacity of consultants. Members of this board are W. H. McAlpine, Dexter P. Cooper, Walter J. Douglas, F. H. Cothran, and Joel D. Justin.

The principal structures that will be required to put the plan in operation are: four rock-fill dams ranging in length from 1,500 to 3,800 feet and in height from 33 to 140 feet; a main power house of ten units, with an aggregate capacity of 122,500 kw., and a substructure for ten additional units; a filling-gate structure consisting of 25 vertical-lift gates each 30x30 feet; a navigation lock; a reservoir for pumped storage, together with a power house of 60,000-kw. capacity; and a transmission line connecting the two power houses. More detailed descriptions, and the quantities of materials needed for all these, exclusive of the transmission line, will be found in connection with the map on the preceding page.

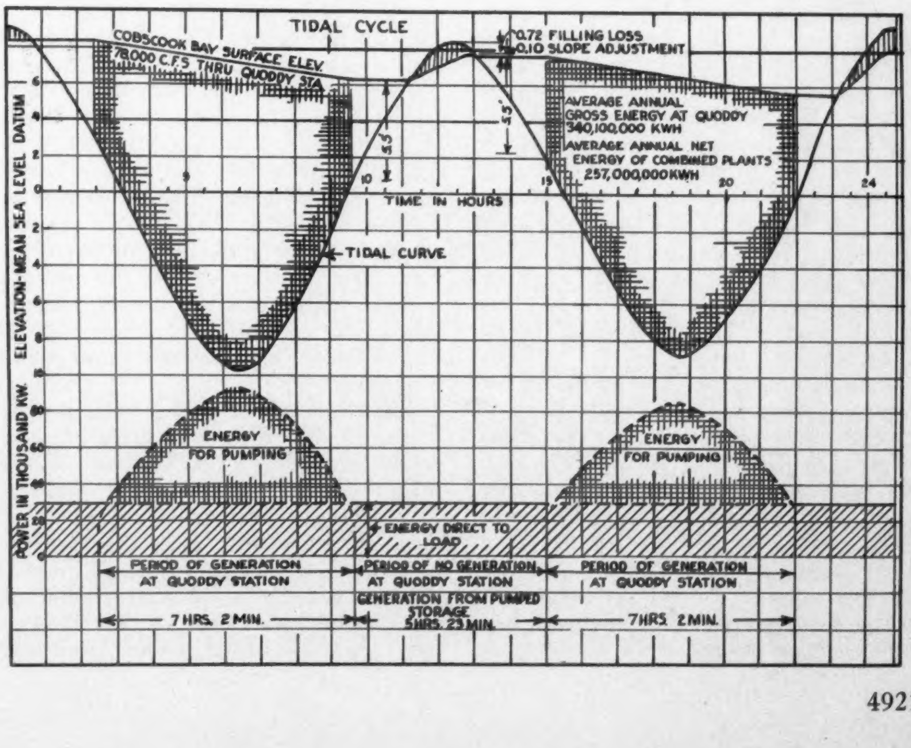
One of the serious problems that will present itself during the construction period is that of coping with the strong tidal flow. Currents having velocities up to 8 knots race through the openings between the islands, and the dams will be designed to resist a velocity of 12 miles

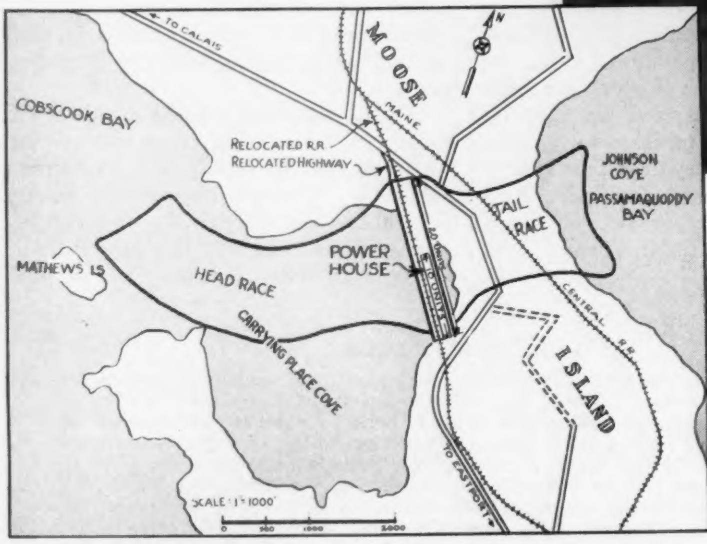
THE TIDAL CYCLE

This graphic explanation shows how the two power plants will combine to produce electrical energy continually. Cobscook Bay, which will be the high-level pool, will be filled when the tide comes in by opening some or all of the 25 individually controlled vertical-lift gates which will be capable of passing 350,000 second-feet of water under normal conditions. When the tide begins to recede, these gates will be closed, and when the difference in the levels between Cobscook Bay and Passamaquoddy Bay reaches 5½ feet, water will be admitted to the draft tubes of the turbines in the power house between these two bodies of water. The head will be as great as 20 feet, but only that obtained from a 5-foot head will be classed as prime power. All power generated at higher heads will be considered surplus power. Some of it will be used to operate nine pumps aggregating 180,000 hp., and these will deliver water to a storage reservoir at a considerably higher elevation.

After 7 hours and 2 minutes of operation, the sea-level generating station will have to be shut down, as the incoming tide will have reduced the head below 5½ feet. There will be an interval of 5 hours and 23 minutes during which the plant will be inoperative. To fill in the gap, water will be released from the storage reservoir through turbines aggregating 60,000 hp. This will be the recurring cycle, and in every lunar day the main plant will run 14 hours and 4 minutes and the auxiliary plant 10 hours and 46 minutes.

There will be a loss of about 35 per cent in pumping and about 15 per cent in generation, so the efficiency of the storage-reservoir power plant will be approximately 50 per cent.





POWER-PLANT SITE

After extensive investigations, it has been decided to locate the main power plant on Moose Island, near Eastport. The neck of land that here separates Cobscook Bay and Passamaquoddy Bay will be cut away to elevation −35 to form the tailrace. The initial installation is to consist of ten units on 80-foot spacing. Each will be made up of a turbine developing 10,300 hp. at 12 feet net head and driving a 12,250-kw. generator. The headrace and tailrace channels will provide for a flow of 8,300 second-feet of water through each of the ten units at a velocity of 3 feet per second. The substructure will include positions for ten additional units. The railroad and highway to Eastport, which now cross the neck of land, will be relocated to pass over piers alongside the powerhouse structure. In the picture above, Passamaquoddy Bay is on the left and Cobscook Bay on the right.

per hour during construction. To make them secure, it will be necessary to use several million tons of rocks, each weighing approximately 20 tons. Prospecting nearby for rocks of such size has thus far failed to reveal a source of supply, and they may have to be obtained from a granite deposit near Calais, some 30 miles away. The formation around Eastport is of sedimentary origin and consists mostly of a sandy shale, exhibiting a tendency to break into small pieces.

The dams will be built by depositing materials from the surface on to the water bed along the projected lines. A railroad trestle, which now carries the Maine Central Railroad tracks into Eastport, will be used for that purpose in the case of the Carlow Island Dam. The others, particularly the Eastport and Lubec dams, will probably be brought up to the water line by the aid of floating equipment. The dams will be constructed to elevation +20. They will be faced with earth blankets on the Cobscook Bay side.

Exploration of the sites where the various structures will rise constitutes one of the most important preliminary operations. Sprague & Henwood, Inc., of Scranton, Pa., is engaged on a $90,295 contract covering core drilling in connection with structures other than the Eastport and Lubec dams. Diamond drilling in water-covered areas is carried on from cribs which are towed to new positions at high tide. Bids for drilling on the Eastport and Lubec dam sites were rejected as too high, and the Government is doing this work. Two large boats, the *Eastern Chief* and the *Eureka*, have been leased and fitted with special paraphernalia to meet the conditions imposed by deep water and strong currents. Aside from the foundation investigations, the engineering department has set up a well-equipped laboratory where samples of corings are analyzed and tested.

As previously noted, one of the first requirements was that of providing living and working quarters for the personnel. Eastport, an old town that considers fishing its leading industry, was ill equipped to serve as a base of operations. As a result, the Government established itself in a variety of buildings, ranging from wharves to churches, until more suitable quarters could be made available. As there are more than 1,000 persons in the administrative, office, and engineering departments, this has led to a confusing segregation of related activities and to no end of congestion.

This condition, however, is being rapidly corrected, for Quoddy Village, located about three miles from Eastport, is now being occupied. This camp, which will cost $1,500,000 when completed, has one of the most attractive and picturesque settings imaginable. It stands on sloping ground, which runs down to the water's edge. It was covered with a heavy growth of evergreen trees; and in the sections given over to residences not a tree was cut down unless it actually interfered with building operations. Thus a large part of the village is hidden in the forest. There is plenty of space between houses, and winding roadways add to the pleasing effect.

Quoddy Village provides living accommodations for more than 1,000 persons. There are 120 homes of the single-, 2-, and 4-family type for 245 families, as well as two 40-family apartment houses, a dormitory for 130 persons, a 20-bed hospital, a guest house, an 8-grade school, a fire station, and structures to house the necessary public utilities. In the Administration Building, which stands on cleared ground near the top of the slope, is office and desk space for 480 persons, including the army officers, engineers, draftsmen, clerks, stenographers, and typists that will be needed during the term of construction. Steam will be piped to all structures from a central 750-hp. boiler plant; and this service will be furnished at a charge of $7 a month. This low rate (the average cost of heating a Maine house in winter is $20 per month), and the moderate rentals will partly offset the low wage scale which applies to many of the workers, as will be mentioned later. Quoddy Village is classed as a temporary camp; but if the hopes of bringing industries to the section are realized, there is the possibility that it may be disposed of to advantage.

In addition to the large force of men employed by the Government for building

CONSTRUCTING QUODDY VILLAGE

More than 10 miles of water, sewer, and steam pipes were laid in the new town. Compressed-air tools were used for the necessary trenching, for excavating foundations for buildings, and for constructing roads. Shown below is one of the three 2-stage, air-cooled portable compressors in service, and at the left is a trenching crew with a "Jackhamer" and a pavement breaker. "Jackbits" are being used on all this drilling work.

QUARRY PROSPECTING

In excess of 5,000,000 cubic yards of rock will be required for building the structures that will inclose Cobscook Bay. Rocks weighing up to 20 tons each will be needed in the larger dams to resist the strong currents to which they will be subjected during construction. Extensive tests have been made in an effort to locate a suitable quarry site near at hand, but it seems that the large-dimension stone will have to be secured from the Calais area, 30 miles distant. Shown below is an X-71 drill, on a Type FA wagon mounting, drilling test holes on Shackford's Head.

Quoddy Village, several contracts were also awarded. Chief among these was one for $493,231 to the J. Slotnik Company of Boston, Mass., covering the construction of the Administration Building, of the two apartment houses, and of the dormitory. Other contracts let were: A. A. Jackson Company, Bangor, Me., $102,595 for plumbing and heating installations; Cleghorn Company, Boston, $64,593 for installing boilers, etc.; Theodore Logan & Sons, Inc., Portland, Me., $48,350 for painting and papering; Pittsburgh-Des Moines Steel Company, Pittsburgh, Pa., $15,700 for tanks.

On a hillside overlooking the site of the main power house, in Carrying Place Cove, nine permanent residences have been erected by John H. Simonds Company of Portland under a $150,632 contract. These will be occupied during the construction period by the army officers and others who are directing the work. Upon completion of the project they will house some of the operating personnel.

To facilitate construction, a shop area has been created at Spring Farm, between Eastport and the main power-house site. Machine and carpenter shops, garages, etc., have been set up there, as well as eight barracks accommodating 50 men each, and a mess hall that seats 400. All lumber designed for Quoddy Village was sawed there to simplify building operations. Incidentally, at the time the work was visited in November, 14,000,000 board feet of lumber had been delivered. Curiously enough, Maine, with all its timber resources, was unable to supply sufficient quantities of seasoned lumber, and some of it was secured from southern mills. Barracks and mess halls for 800 men have been built at Deep Cove, near the main power-house site.

As was previously stated, one of the reasons for starting the Passamaquoddy development was to furnish employment to persons then on relief. The rapidity with which this was done is attested to by the records, which show that from June to the middle of November the force grew from nothing to 4,497. Approximately 60 per cent of those hired directly by the Government were taken from relief rolls, and an additional 30 per cent comprised persons who were unemployed but not receiving relief. The remaining 10 per cent was made up chiefly of artisans who were necessary to the conduct of the work. For example, skilled carpenters were needed for some of the building activities. About 200 persons in the engineering department have been transferred to Eastport from other sections of the country. All have Civil Service status.

In keeping with the Government's policy not to make the wage scale for PWA projects high enough to divert labor from private industry, the individual pay envelopes at Passamaquoddy are not bulky. The maximum rates of payment per month are $44 for common labor, $50 for intermediate labor, $63 for skilled labor, and $69 for professional and technical workers. Twenty per cent of the respective amounts is charged for board and lodging when the workers elect to take advantage of the Government facilities. In addition to the Government force, there were 746 contractors' employees on the job on October 30. Contractors are required to pay at least 40 cents an hour for common labor and 75 cents for skilled labor. Most of the contractors maintain accommodations for their men. The total payroll for the week ending November 9 was $83,963.

Passamaquoddy is the only PWA project underway in Maine. It is the intention to spread the work out over a period of four years. For the remainder of the present winter the government force will probably be reduced to around 2,500 persons.

The Grossglockner Highway

Robert Peen

GENERAL VIEWS

The pictures on this page show typical sections of the roadway, which unfolds a new, magnificent panorama at every turn.

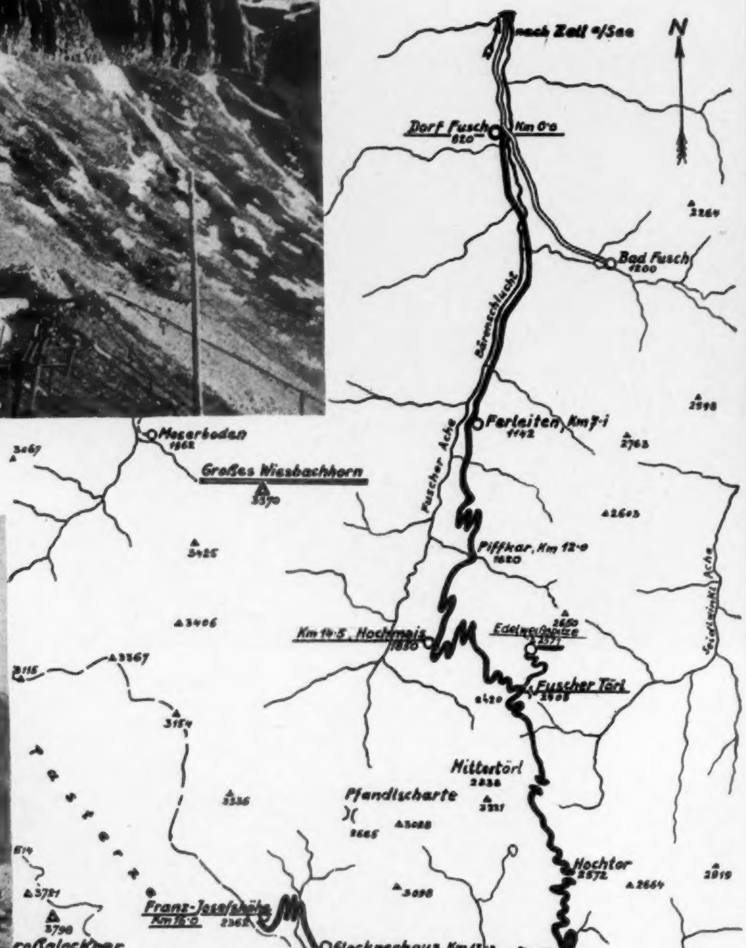
WITH the completion of the Grossglockner-Hochalpenstrasse or highway across the Alps, the Austrian Government has added another to her many outstanding tourist attractions and, what is of more economic importance, has provided a short cut for motor traffic between the countries lying north and south of that great mountain barrier. Some of our readers may recall that we published an article on this subject in our April, 1933, issue; but at that time the most difficult part of the work—the actual crossing of the ridge—had not been undertaken. It is with this part of the road job that we are now going to deal; and in order to refresh our memories we shall give the salient features of the entire project.

From end to end, that is, from the Village of Fusch at the northern terminus of the highway to Heiligenblut at the southern extremity, the Grossglockner-Hochalpenstrasse has a length of approximately 25 miles, not including the two side roads extending from Fuschertörl to the Edelweisspitze and from Palik to Franz-Josefshöhe. The former is a mile long and the latter about 5.5 miles, giving a total of about 31.5 miles of roadway constructed. But it is the altitudes that tell the story of what the work actually involved and what the contractors had to contend with.

Beginning at a point 2,690 feet above sea level, the main highway climbs steadily to Fuschertörl at elevation 7,939. From there it extends for a distance of approximately 3.7 miles at an average altitude of 7,874 feet, reaching its maximum height at Hochtor, 8,221 feet above sea level, and descend-

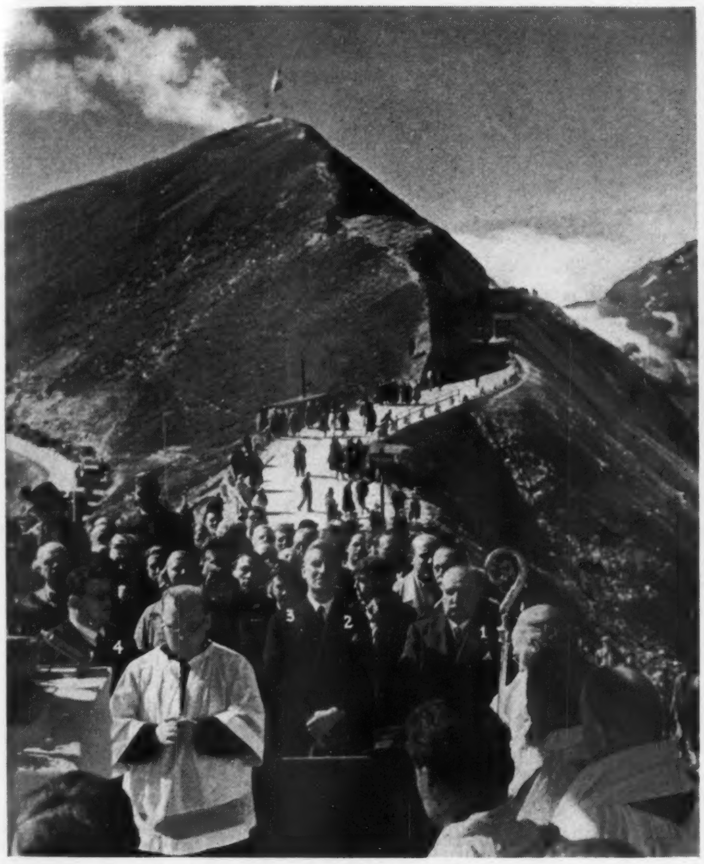
AT FUSCHERTOERL

The large picture shows drillers at work on one of the heavy cuts near Fuschertörl while snow was still lying on the ground. The view at the right is another and later one taken from approximately the same point. In both of them the Grossglockner appears in the distance. Two stretches of the finished highway are reproduced below. The bottom one indicates the serpentine course that was followed in some places to gain elevation.



TUNNEL DRIVING

Two tunnels were required in the southern stretch of the road. These three pictures show work underway on the bore at Mittertörl. At the upper right is a map of the highway. It extends for a distance of 25 miles, climbing from elevation 2,690 at its northern end to elevation 8,221 at the crest, and then descending to elevation 4,245 at its southern extremity. In addition, there are two side roads for tourists that total 6½ miles in length.



THE PUBLIC OPENING

The Bishop of Salzburg (left) asking a blessing on the work in the presence of President Miklas (1) and Chancellor Schuschnigg of Austria (2), Mrs. Schuschnigg (3), and the governor of the province and town of Salzburg (4). This ceremony marked the opening of a part of the road on September 23, 1934. Above are Austrians from nearby Zell-am-See as they appeared at the celebration in their native costumes.

ing thence to Heiligenblut lying at an altitude of 4,245 feet. At Hochtor and a little farther north at Mittertörl the road has been carried through tunnels. Despite these differences in elevation, the grades can be negotiated without difficulty by modern motor cars. The steepest does not exceed 12 per cent, and the majority range from 9 to 10 per cent. With the exception of curves and cuts, the highway has a general width of 19.7 feet, sufficient to accommodate two lines of traffic. At curves, which have a radius varying from about 26 to 33 feet, it is widened out to as much as 36 feet, while it is limited to 18.5 feet in cuts. It is surfaced with macadam.

The two side or secondary roads have been constructed primarily for the benefit of the sight-seeing public. They terminate at lookouts on the crests of the towering Franz-Josefshöhe, at elevation 7,749, and of the Edelweisspitze, at elevation 8,435. At the latter vantage point, the highest reached by the builders, there is a parking place for automobiles. From those lofty eminences, heretofore inaccessible to the average tourist, one commands a sweeping view of the majestic Glockner Range with the 12,460-foot-high Grossglockner and a glacial world covering an area of approximately 11.5 square miles.

Operations on the northern and southern ascents, and on the Franz-Josefshöhe branch were finished a year before the route of the connecting link had been decided upon. It was realized that the job was an extremely difficult one because of the character of the region traversed; and in order that no mistakes might be made it was deemed wisest not to go ahead until various problems in connection with it had been thoroughly investigated. Accordingly, Austrian and Swiss experts in the construction of alpine highways were invited to go over the ground and to determine the best possible right of way across the rocky ridge. Furthermore, well-known alpinists were consulted, as the dangers of enveloping avalanches must always be reckoned with in such a country and at such altitudes.

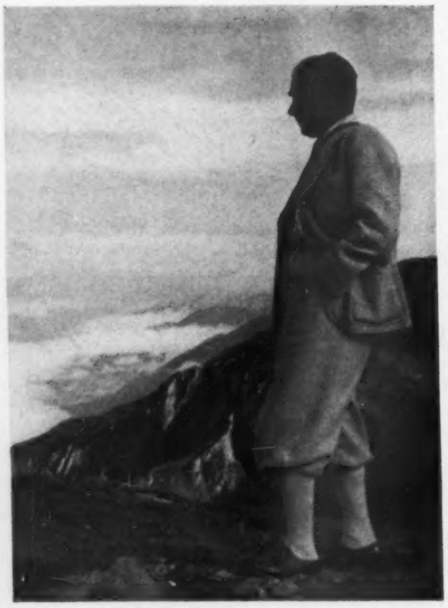
Three different routes were proposed on the strength of these investigations, and each in turn received careful consideration. The outcome was that the one initially laid out by Oberbaurat F. Wallack, under whose supervision the Grossglockner-Hochalpenstrasse was built, was chosen by the government. It passes through Hochmais, Fuschertörl, Mittertörl, and Hochtor, and follows generally the trail blazed by the Romans centuries ago. Traces of the ancient roadway are still visible here and there in the form of deep cartwheel ruts; and added proof of the fact that Caesar's legions passed that way was discovered soon after work on the last stretch of the highway was begun.

While excavating for the tunnel at Hochtor, at elevation 8,221, one of the workmen found a bronze statue of Roman origin. It stands about 8 inches high, and represents Hercules bearing a lion skin. It is said to date as far back as the fifth century B.C., and is assumed to have been placed in a shelter hut at the top of the southern ascent possibly as an inspiration to the soldiery on their toilsome march across the Alps. Hercules, as most of us know, was a god worshipped by the Romans for his warlike strength and riches; and to him they offered sacrifices in the form of spoils from the battlefield.

The contract for the connecting link, together with the side road to the Edelweisspitze, was awarded to three Vienna contractors: Universale-Redlich & Berger, Polensky & Zoellner, and to the Baugesellschaft A. Porr. This was in the fall of 1933; and as the season was already too well advanced for actual roadbuilding, it was decided to get the camps in readiness and the machinery and equipment in place before winter set in. It should be mentioned here that while it was possible to count on a construction period of from six to seven months a year on the lower sections of the highway, work at altitudes of 6,561 feet and upward was limited to five months; and even that short season was likely to be curtailed by reason of unfavorable weather conditions.

A force of 2,000 workmen was employed on the job; and to adequately accommodate them in that bleak and barren region it was necessary to erect 100 houses. These were delivered in sections; but before they could be transported to their respective sites, the contractors had to build temporary roads over which they could be hauled by crawler tractors. Not until after they were ready for occupancy could the plant and equipment be moved in and set up.

Two aerial cableways and a hoisting in-



THE BUILDER
Oberbaurat F. Wallack, who laid out the road and supervised its construction.

cline served to transport the machinery, materials, and supplies. The difference in elevation of the cableway on the north side of the mountains was 984 feet and that of the one on the south side was 2,054 feet. Power plants also had to be provided: one at the southern end and another, a diesel-electric, at the northern end. The former distributed current for a distance of six miles over transmission lines strung across generally inaccessible country. The two stations furnished power for operating the cableways, stationary compressors, etc. In addition to the latter, a considerable number of portable compressors was also in use. These were of Ingersoll-Rand make and included size 5½x5, 7x6, and 9x8 Type 20's, as well as some of that company's new Type 125 units which are driven by oil engines. The last-named, because of their 2-stage construction, proved to be especially satisfactory at high altitudes, and showed no appreciable loss in efficiency when stationed at points more than 8,000 feet above sea level. Another advantage in their favor was the lower cost of the fuel burned—heavy oil being 68 per cent cheaper than gasoline in Austria.

Early in May of 1934 work was started at points along the line below elevation 7,874, but not until the beginning of July was anything done in the higher reaches. Even then the contractors encountered great difficulties, because long stretches of the right of way were covered with snow from 10 to 13 feet deep, and this had to be removed before drilling and excavating could be undertaken.

Despite the fact that adverse weather conditions greatly hindered operations during the succeeding summer months, the building program was carried out as scheduled; and when autumn came and put a stop to activities, it was possible to report the section of the road between Hochmais and Fuschertörl completed, as well as the branch leading thence up to the Edelweisspitze. That part of the highway was officially opened to traffic on September 23, 1934, in the presence of President Miklas, Chancellor Schuschnigg, and other Austrian dignitaries.

The section immediately to the south, between Fuschertörl and Hochtor, involved the construction of the two tunnels. The one at the latter point is 1,023 feet long, and the other at Mittertörl has a length of 384 feet. Both were driven 24.5 feet wide and 15.75 feet high and lined with stone, giving them an inside width of about 17.5 feet, which is sufficient for two large vehicles to pass each other. On either side are footpaths, each 2.75 feet wide, protected by iron railing. The tunnels are electrically lighted, and both of them have sliding gates at their respective ends. They also have guardhouses. For the purpose of controlling the road from end to end, a special telephone system has been installed with boxes at intervals of 1.25 miles. This is also available to the public. Wherever space permitted, parking places have been built so as to enable motorists to view at leisure the ever-changing panorama of pleasing valleys and austere mountains that is presented the entire way.

Everything was done by the contractors and the government to make the workers as comfortable as possible in their isolated camps. Adequate mess halls and hospital facilities were provided, as well as social rooms, where games of all sorts were at their disposal, and libraries stocked with books and newspapers. Through the cooperation of the Government Cinema Service and the People's Educational Institution in Vienna, moving pictures were shown at intervals, and these were very popular with the men. A priest, Father Franz Stiletz, was also assigned to them by the church, and he had his base at Oberes Nassfeld situated between Fuschertörl and Mittertörl and 7,414 feet above sea level. There, as the "Glockner Priest," he conducted religious services on Sundays and holidays, no matter what the weather, and at other times devoted himself to the care of the sick.

The end of the 1935 building season saw the contract completed, and on August 4, 1935, the Grossglockner-Hochalpenstrasse from Fusch to Heiligenblut was formally dedicated. It is of interest to note that that date coincided with the celebration held in commemoration of the opening to traffic of the double-track Arlberg Tunnel just 50 years previously. That tunnel is 9.3 miles long and lies at an altitude of 3,937 feet. It is a link in the railway line connecting Paris and Vienna, and is one of the important tunnels in the Alps.

Austria has had much experience in work of this kind. Her Semmering railway, which was finished in 1854, is the oldest of the great continental mountain railways and is remarkable for its many and long tunnels, its viaducts, and its galleries. With the construction of another transalpine road, this time for vehicular traffic, she has added one more to her outstanding engineering achievements of this nature. And it is still more to her credit when it is realized that the project was undertaken and carried to conclusion in the face of unfavorable economic conditions so as to help reduce unemployment.

OIL-ENGINE-DRIVEN COMPRESSOR
At various places the highway crosses or follows one of Caesar's military roads, which was built solely by hand labor. In contrast, the Grossglockner-Hochalpenstrasse was put through with the aid of modern compressors and rock drills. Below is one of the several portables which were used to augment the air supply from a central plant of stationary, electrically driven compressors.

A Theater of the Stars

Allen S. Park

EXTERIOR VIEW OF THE PLANETARIUM

PICTURE the visible world compressed within a half-globe 75 feet across. It is night, and you are sitting in Central Park, New York City. Towers of masonry and steel form a serrated silhouette against the horizon. Overhead the cloudless sky is studded with a veritable fairyland of celestial bodies. Out of the semidarkness comes a voice. It speaks of the North Star, the Big Dipper, the better-known constellations, and the planets, and as each is mentioned a magical arrow of light points it out to you. Suddenly the planets begin to move. They travel much faster than you have ever seen them go before, for in this mimic world in which you now find yourself a year is not 365 days, but a mere matter of minutes—even as little as seven seconds, if we choose to make it so. The sun comes up and glides across the spanning dome. The moon joins the parade, changing to its various phases with clock-like precision. For 45 minutes the heavens perform for you. Time is moved backward or forward at the will of an unseen stage manager. In a trice you are transported to the north pole to have a glimpse of the outer world from there. A few seconds later you are at the equator.

The foregoing inadequate description is intended to convey a general idea of the spectacle that awaits the visitor to the latest theater of the stars—the Hayden Planetarium in New York City. It is all make-believe, of course, but so skillfully is the show staged and presented that it seems very real indeed. Although it has been open only a few weeks, the planetarium is already one of the city's foremost attractions. Six regular exhibitions a day are offered, in addition to special showings, by arrangement, to groups, and the indications are that the schedule will have to be increased to accommodate the crowds.

CHARLES BOYLE, fourth Earl of Orrery, a British author, soldier, and statesman who lived from 1676 to 1731, was interested in astronomy. To portray the motions of the solar system, he had made for himself an instrument consisting of balls actuated by wheelwork. Such a device has since been known as an orrery, or Copernican planetarium. It was the only practical aid in the teaching of astronomy until, a few years ago, three scientists in Germany collaborated to produce one of the marvels of our times—the projection planetarium.

Strangely enough, some of the other parts of this country, and virtually all of Europe, know more about planetariums than does usually ultra-modern New York. Philadelphia, Los Angeles, and Chicago each had one before the nation's largest city. The Chicago planetarium was one of the leading features of the Century of Progress Exposition. There are eighteen of them in Europe. But the New York planetarium, because it is the most recent one built, is probably the finest of them all, for it represents the culmination of all the experience that has been gained in erecting and operating such show places.

The planetarium of which we are speaking is known as the Zeiss type, because it was devised with the aid of the Carl Zeiss optical works at Jena, Germany. The principle upon which it depends—that of projecting the heavenly bodies upon an artificial sky with a glorified magic lantern —was conceived by the late Dr. Oskar von Miller, creator of the famous Deutsches Museum in Munich, and by Prof. Max

Wurts Bros. Photos

SOLAR SYSTEM

This Copernican planetarium, or orrery (above), occupies the room directly beneath the projection planetarium. The sun is represented by a lighted globe in the center. Around it revolve the globular planets at their relative speeds.

EXHIBITION SPACE

On two floors are spacious hallways containing displays of astronomical phenomena and illuminated photographs set in the walls. One of them is shown at the left.

Wolf of Heidelberg. The Copernican planetarium, a mechanical arrangement for showing the motions of the planets and their satellites, had previously constituted the foremost means for teaching astronomy graphically. For his museum, Doctor von Miller wanted something better. He sought a way to dramatize the happenings in the heavens. He consulted Professor Wolf about the problem, and fortunately so, for the latter unfolded his idea of a projection planetarium that had been growing in his mind for a long while.

Von Miller was enthusiastic about it, and thus it came about that the Zeiss works was asked to build the essential equipment. That was in 1913. Dr. W. Bauersfeld, a Zeiss engineer, undertook to develop a projector flexible enough and precise enough to flash the images of the stars upon an improvised sky and to portray accurately their movements, past, present, and future. It took him twelve years to accomplish this to his satisfaction. By that time the Deutsches Museum had been virtually completed, but so anxious was von Miller to include the planetarium that a part of the huge structure was made over to accommodate it.

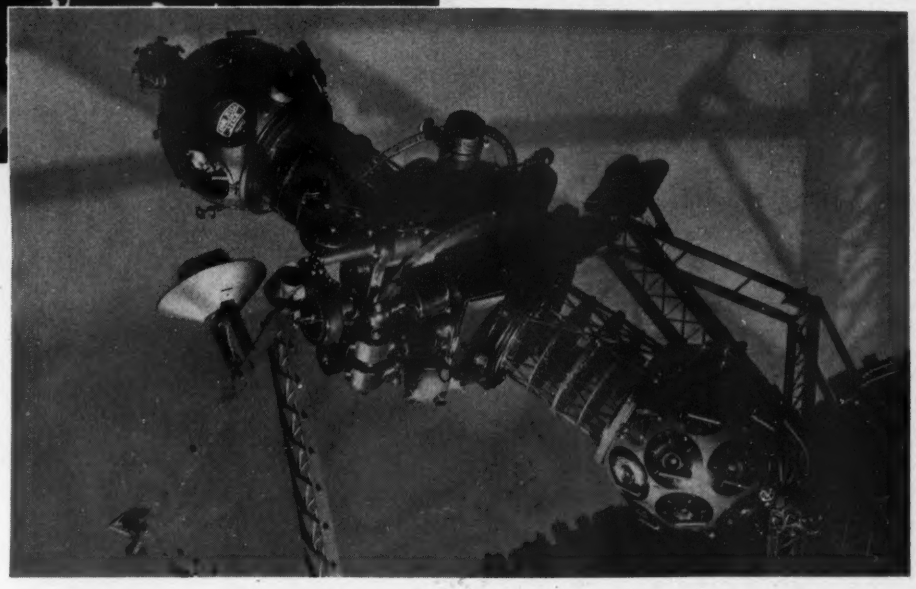
The result was so satisfying that other European centers took up the idea, and Doctor Bauersfeld designed the optical equipment for more than twenty additional planetariums. All of them, as well as those that have been erected in the United States, follow the original plan, with only such modifications and improvements as have been deemed advisable in the light of continually widening experience.

New York City gained its planetarium through the generosity of a private citizen, plus the policy of the Federal Government to lend money for public works to accelerate employment. Charles Hayden, prominent in financial circles, gave $150,000 with which to buy the required apparatus. In appreciation of this gift the planetarium was named for him. From the Reconstruction Finance Corporation, the American Museum of Natural History borrowed $650,000 for the construction of the building. This sum is to be repaid from admission fees, after which the planetarium will probably be open to the public free of charge. Patronage to date indicates that the investment can be fully amortized in not more than twenty years.

The projector, resembling a huge dumbbell, is 12 feet long, and is mounted at its midsection so that it may be raised, lowered, or rotated on three axes at will. It is studded with protruberances, each of which is there for a specific purpose, for this superstereopticon consists of 119 individual projectors. The lantern slides are not glass, but thin plates of copper pierced by properly located holes through which the light is projected by powerful lenses. Some of these openings are too small to be seen by the naked eye, but all are of the correct, relative sizes to portray the heavenly bodies in their proportionate dimensions. The projectors are controlled by push buttons; and the movements of the apparatus, through which the courses of the heavenly bodies are traced on the overhead dome, are effected by electric motors. Appropriate incidental music, which accompanies the display at certain stages, is produced by phonograph records and introduced into the room through four amplifiers near the top of the dome.

Facilities are provided for the projection of about 9,000 stars. This number, according to the lecturer, is the greatest visible to a person of the finest eyesight from the most favorable vantage point on the

Wurts Bros. Photos



THE CELESTIAL CIRCLES

The celestial equator, the ecliptic, and the meridian are projected against the artificial sky (above), rendering it easy to visualize their significance and showing their relations to one another.

THE PROJECTOR

This multilensed stereopticon (right), the remarkable creation of Dr. W. Bauersfeld of the Zeiss optical works at Jena, Germany, makes possible the modern planetarium.

clearest of nights. The Milky Way, it is pointed out, consists of thousands of stars; but they are so remote from the earth that none of them can be distinguished by the eye alone. To make it easier to see them, individual stars have been magnified so that they appear as they would through a 3-inch telescope.

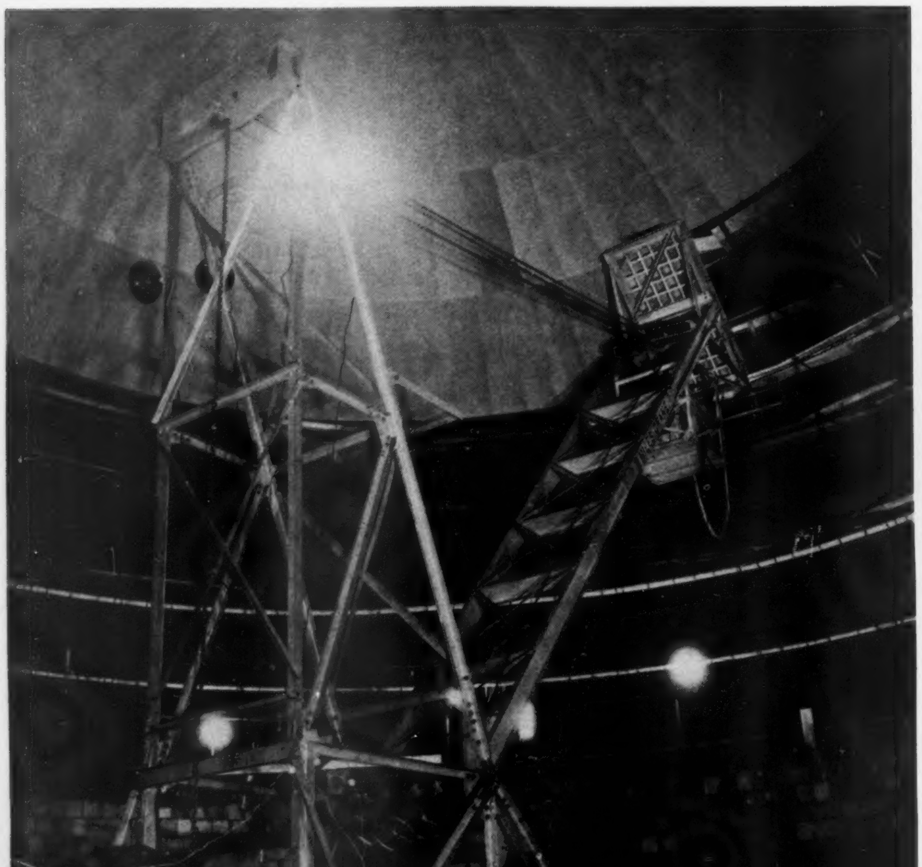
There are 2,187 possible combinations that can be obtained with this magical projector. As already mentioned, time can be turned forward or backward at will, and thus the firmament can be viewed as it was in Biblical times or as it will be centuries hence. Similarly, the latitude of the viewpoint can be instantly changed through the complete range from pole to pole. It is intended to vary the lecture twelve times a year. Thus the story that the planetarium unfolds will never grow old, and regular attendants will be able to obtain a liberal education in astronomy. There are at present seven lecturers, all drawn from the staff of the American Museum of Natural History. By appearing in turn, none is obliged to assume the rôle of master of the universe more than twice daily.

Naturally, the building for the planetarium had to be constructed for the purpose, and it presents some features of interest. It houses not only the planetarium, itself, but also the astronomic section of the museum. Such a structure was first considered some ten years ago; and in the interim an exhaustive study was made of planetariums in this country and abroad, and numerous authorities were consulted to secure general and technical information that would be helpful when it came time to prepare actual plans. In this work the museum staff was assisted by the New York architectural firm of Trowbridge & Livingston, under whose direction the building was erected.

The structure is 146x122 feet in plan, and has a basement and two stories with a surmounting dome, 81 feet in diameter, sheathed on the outside with copper to which the appearance of age has been imparted by artificial treatment. The site selected, adjacent to the group of museum buildings, had once been a pond; and as excavating proceeded it became evident that the materials with which it had been filled had not become stable enough in 40 years' time to support the planetarium. Accordingly, to insure a base of adequate strength, it was necessary to drive 326 hollow steel piles, which were filled with concrete. Because loose rock stopped the progress of the piles, 42 open pits had to be dug to a depth of 10 feet below the basement level before driving could be accomplished.

The most interesting part of the building from a structural standpoint is, of course, the dome. It is a hemispherical shell of concrete that is entirely self-supporting and has an uppermost section only 3 inches thick. At a point 9 feet above the springing line or base the thickness increases to 3½ inches, while its lower 18 inches constitutes a concrete ring 12 inches thick and bearing on the steel frame of the building proper. Reinforcement in the shape of ¼-inch, round, steel rods is embedded in the concrete and arranged to give maximum strength. The dome is in reality a strong structural form, in that it consists of an indefinite number of arches all starting at the base and all intersecting at the crown.

There are many examples of dome construction in Europe, one of the oldest and most famous being that of St. Peter's Cathedral in Rome. It is 9 feet thick throughout its lower quarter, the remaining three



Courtesy, Johns-Manville

THE INNER DOME

Stainless-steel sheets being pieced together to form the planetarium ceiling and projection screen. A special crane, traveling on a circular track and having an extensible arm with a platen at the end, was used in the erection.

quarters being made up of a double shell. Since it was erected there has been a continual reduction in the thickness of domes until the climax was reached with the shell structure. It was first made use of in the planetarium at Jena, in 1924, and subsequently in numerous European structures. It is now being adopted in this country; and the Hayden Planetarium dome is the largest thing of its kind yet attempted here. It not only stands without the aid of trusses or other external features but also supports the inner or projection dome, weighing approximately 15 tons, which is suspended from it by hangers.

The outer dome was cast in place by blowing concrete against an underlying form with Akeley cement guns employing compressed air. The concrete was applied in two weeks. The thin exterior copper sheathing previously mentioned was laid on the concrete. The form used in concreting was a self-supporting structure of wood latticework. To its outer surface was fastened a 1½-inch layer of rock cork to which, in turn, the steel reinforcing rods were wired. After the concrete shell had set, the latticework was removed, leaving the rock cork which thereby became the inner surface of the dome. The purpose of the rock cork is twofold: it serves as an insulator and also as a sound dampener.

The inner dome, which is alike the ceiling of the auditorium and the artificial sky upon which the stars are projected, is suspended from the concrete shell by hangers attached to T-shaped bar anchors embedded in the concrete. It is hemispherical in shape, and exactly 75 feet in diameter. It consists of approximately 10,000 square feet of stainless steel, and was fabricated by spot welding together 561 plates, of 20-gauge thickness, which overlap one another ⅜ inch at the edges. This work was done with the aid of a steel derrick traveling on a circular track and having an arm which could be extended to reach any point in the ceiling. At the outer end of this arm was a curved copper platen, and on this the welding was done.

The inner dome is actually a huge sieve, for it is perforated with round 1/16-inch holes spaced 3/16 inch apart. There are more than 20,000,000 of these openings; but they are so small that they do not affect the efficiency of the surface as a projection screen. They serve as an outlet for the speaker's voice and for other sounds, which are absorbed by the rock-cork lining of the outer dome. The inner surface of the steel dome was coated with flat white paint, thus assuring a satisfactory projection screen without filling up the holes.

The comfort of visitors was not overlooked in equipping the planetarium, and the seats provided for them were selected with that in mind. They tilt back 10°, and otherwise are so designed that observers can remain relaxed while turning their bodies and heads in order to see the various sections of the artificial sky. There are seats for 733 persons.

One of the primary comfort considerations was that of ventilation and air conditioning. It was, in fact, essential, for there are no windows above the basement save those in a row of offices extending along one side of the second floor. It is therefore necessary not only to supply virtually all the air but to provide suitable means for circulating it and for withdrawing it at a rate that will maintain its purity at a desirable point. Moreover, the layout of the building and the conditions governing its use are such as to call for the separate handling of the air destined for different sections of it. For example, the dome-shaped room, which is the planetarium proper, is unoccupied except when shows are in progress. It fills up quickly with as many as 733 persons, who remain there, with all doors closed to exclude light and sound, for 45 minutes. Then all leave within the space of a few minutes. Directly beneath the planetarium, on the first floor, is the solar-system room—a round inclosure, on the ceiling of which the movements of the sun and planets are portrayed by mechanical models. This room is ordinarily visited by a considerable number of persons before and after each performance in the planetarium upstairs, but at other times it is comparatively empty. Surrounding the centrally located rooms on both the first and the second floors are spacious corridors housing astronomic exhibits of various kinds. These halls, likewise, are visited chiefly before and after planetarium shows; but, because of their greater aggregate size, the maxi-

Courtesy, Johns-Manville

THE DOME UNDER CONSTRUCTION

In building this 80-foot half-globe, latticework was covered with rock cork against which was blown a thin shell of concrete by means of air guns (above). The exterior was then sheathed with copper.

mum concentration of people does not reach that which obtains in the planetarium, or even in the solar-system room.

The task of designing a suitable ventilating and air conditioning system to meet the requirements was placed in the hands of Tenney & Ohmes, New York consulting engineers on air conditioning. The installation which was made under their direction embraces equipment for introducing an adequate supply of fresh, outside air; for cleaning it; for conditioning it as regards temperature and humidity; for circulating it; and for withdrawing stale air from the building.

For these purposes, three separate but similar ventilating systems are provided. These serve, respectively, the planetarium, the solar-system room, and the exhibition halls. It is thus possible to deliver air to any one of these independent of the others. Furthermore, the volume of air circulated by each can be varied in accordance with the needs, as determined by the number of persons concentrated each day in the particular section served by that system.

The three ventilating units are grouped in a corner of the basement. As all are alike, a description of one will suffice. Each unit has two fans, one for sucking air into the building and the other for exhausting it. Fresh air is drawn in from outside through a downtake, and conducted to the supply fan through a large duct of rectangular section. On its way to the fan it is conditioned in a series of steps.

First among the varied items of equipment for this service is a filter for removing dust and other suspended matter. Next is a tempering stack of cast iron. The purpose of this is to heat the air at times when its temperature is below the comfort point. This is done by passing it through Vento heaters, which are radiatorlike structures through which steam at 2 pounds pressure is circulated. The installation is capable of heating the full volume of intake air from zero to 65°F.

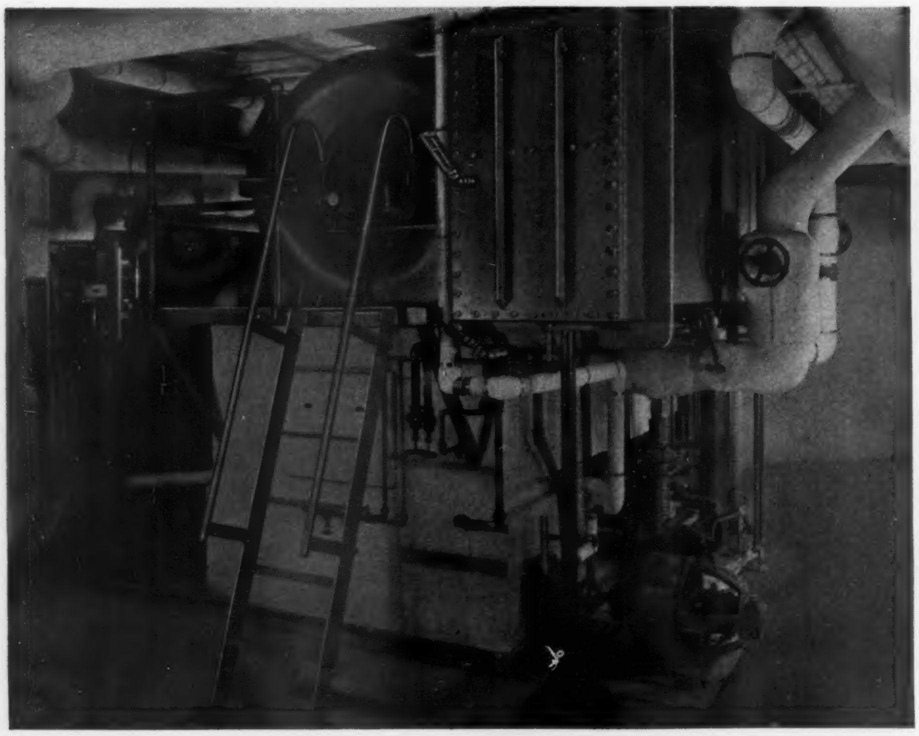
Next in line are cooling coils for reducing the temperature of the air during the hot-weather period. These units, which are manufactured by the Trane Company of La Crosse, Wis., consist of a bank of tubes with a header at either end, and, save that there are transverse fins in the tube sections, resemble conventional heat exchangers or intercoolers in their construction. Chilled water, which is supplied by a water-vapor refrigerating unit that will be described later, is circulated through the coils. Because of the condensation of moisture, or sweating, which takes place when the air is suddenly cooled by contact with them, they are made entirely of nonferrous metal to prevent corrosion. The headers are bronze and the tubes are galvanized copper.

The final unit in the series is an air-moistening coil. This is a boxlike structure, open at the top, containing a pipe coil through which steam is circulated. In winter, when the outside air is normally too dry for healthful breathing, the container is filled with water. As this is evaporated by the heat of the steam, the vapor is taken up by the air stream. The flow of steam is automatically controlled by a humidistat, which opens or closes a diaphragm valve as conditions may warrant. In times of warm, humid weather, excess moisture is removed from the air by reducing its temperature, as may be required, by means of the cooling coils. To bring it up to a comfortable temperature prior to its circulation, the air is passed over the steam coil. To prevent the reintroduction of moisture during such periods of operation, the water is withdrawn from the coil box. Humidistat control of the steam is not used in the summer, the diaphragm valve being regulated by a thermostat placed in the air-supply duct.

When it came to selecting the type of refrigerating apparatus best adapted for the purpose of supplying chilled water for the cooling system, it was soon found that the conditions were favorable to a water-vapor machine. This type, it was determined, employed only water as a refrigerant, and would therefore assure positive protection against the chance liberation of irritant vapors in a building that would be frequented by crowds. It would also make unnecessary the handling and storage within the structure of a chemical refrigerant.

The conditions were exceptionally favorable to the economical operation of a steam-driven refrigerating machine, as there was available a sufficient volume of exhaust steam from engines utilized to drive electric generators in the nearby power plant of the museum. This steam, of approximately 2 pounds pressure, was used for heating during the winter months; but in the warm-weather seasons it was wasted. Accordingly, with power for operating a steam-driven refrigerating machine assured at virtually no cost, the unit ordered was designed to take advantage of this circumstance.

The machine is an Ingersoll-Rand centrifugal-type water-vapor unit in which



SOURCE OF CHILLED WATER

This water-vapor refrigerating unit supplies water at 46°F. for conditioning the air in the planetarium in warm weather. Vapor withdrawn from the evaporator is compressed to the condensing point by a centrifugal compressor, which is driven by a 120-hp. turbine using steam from the exhaust of engines that drive generators. The unit is rated at 150 tons of refrigeration. The picture shows the circular end of the compressor, with the condenser at its right and the evaporator below it.

the water to be cooled is admitted to a high-vacuum evaporator where a small portion of it vaporizes and thereby cools the remainder. The chilled water is removed and delivered for use by a pump, while the vapor is drawn off and compressed to condensing pressure by means of a centrifugal compressor. It has a rated capacity of 150 tons of refrigeration when operating with steam at 1 pound pressure. The compressor is driven by a direct-connected 120-hp., Moore steam turbine. Normal service conditions call for chilling the water to 46°F., but lower or higher temperatures can be readily obtained if desired.

The unit has two condensers inclosed in a single shell—one for the water vapor discharged from the compressor, and the other for the steam exhausted from the turbine. City water is used for condensing. It first goes through the water-vapor condenser and then through the turbine condenser, after which it is wasted.

There are two built-in Cameron pumps, each of 250-gpm. capacity, for handling the chilled water. One of these serves as a spare. There are two additional Cameron pumps—one of them a spare—for draining the condensers. A steam-jet air ejector evacuates air from the vapor condenser into the turbine condenser. For maintaining vacuum in the turbine condenser and for removing air from it, there is an Ingersoll-Rand rotary dry vacuum pump. All the pumps are motor driven.

Having been thus purified and conditioned, the air is distributed by the supply fan through a series of ducts and branches to the part of the planetarium which it serves. Return air is collected in the reverse order by the exhaust fan. The discharge line from the exhaust fan is divided, one branch leading out of the building and the other one back to the intake of the fresh-air supply system. By manipulating a damper, it is thus possible to recirculate all or any portion of the air. The advantage of this is that in warm weather, when the building is empty, it can be cooled to a desirable temperature quickly.

The air is introduced into and withdrawn from the conditioned spaces through wall louvers the locations of which vary. In the planetarium, the inlets are about 7 feet above the floor, and the louver boards are set at an upward angle of 45°. The outlets are near the floor. In the solar-system room the air enters near the ceiling and is withdrawn near the floor. In the exhibition halls, inlets are close to the ceiling and outlets are placed in both the upper and lower parts of the walls.

The total capacity of the three systems is 59,000 cfm. of supply air and 49,100 cfm. of exhaust air, made up as follows:

	SUPPLY	EXHAUST
Planetarium	17,380	14,770
Solar system	9,900	8,410
Exhibit spaces	31,720	25,920

In computing the air requirement, it was assumed that the greatest concentration of people in the exhibition rooms would be an average of 1 person to 40 square feet of floor space. On this basis, the volume of air furnished provides 20 cfm. for each. The supply in the planetarium amounts to about 23 cfm. for each person with all seats occupied. The capacity of the solar-system room was estimated to be 250 persons, and on that assumption the volume of air per person is 39 cfm. However, it is expected that this room will later be used for showing motion pictures, and that seats will be installed to accommodate 430 persons. Under those conditions, the air allowance per person would be cut down to 23 cfm. As all the fans are driven by variable-speed motors, any or all of the systems can be operated at partial capacity if desired. In addition to the main systems, there are two separate exhaust systems—one serving the buildings and lavatories, the two others motion-picture projection booths which are on one side of the planetarium.

Aside from the provisions for heating the circulating air to a comfortable temperature, the building is equipped with steam-heating units for use during cold weather. These are concealed radiators placed in wall ducts having a rise of 6 to 8 feet from the point of intake to the discharge. The increase in temperature, and consequent lightening of the air as it passes through these heated ducts, induces considerable circulation by convection.

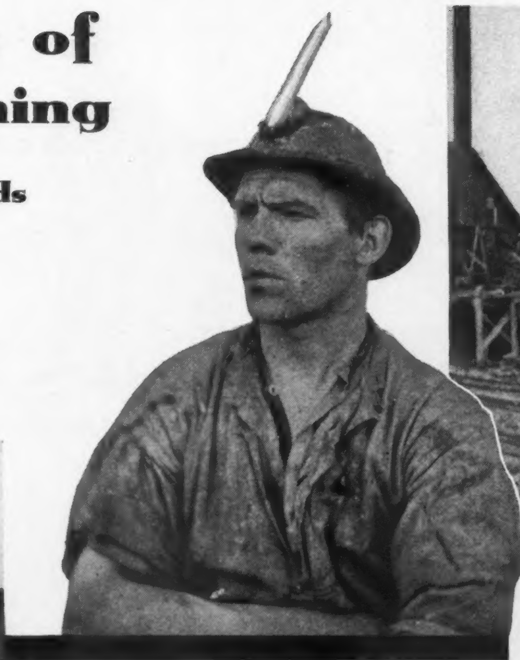
It is an interesting fact that only eight radiators, each with but 50 square feet of surface, are provided for heating the planetarium, and all of these are located overhead in the space between the projection dome and the outer dome. They suffice to radiate enough heat because of the great amount of body heat given off by the people, who are seated close together during the exhibitions. Furthermore, the rock-cork lining, or insulation, of the outer dome prevents the outside temperature from appreciably affecting that within.

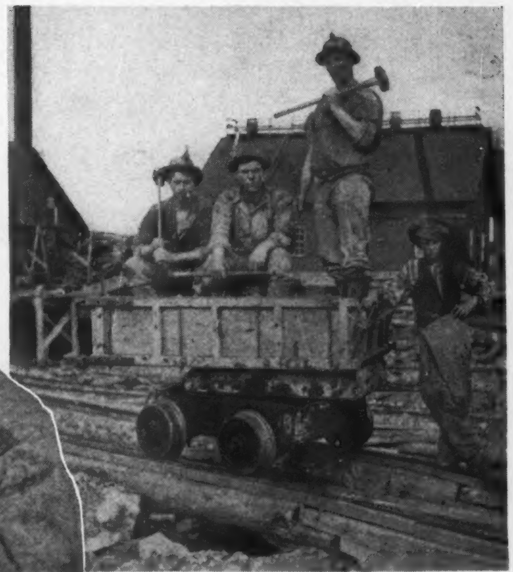
It should be mentioned that it would have been possible to provide complete automatic control for the ventilating and air-conditioning systems. However, it was decided that the size of the installation and the capital invested justified continual supervision. Accordingly, an operator is on duty whenever the building is open to the public. Nevertheless, by the adoption of water-vapor refrigeration, this supervision during the cooling season has been reduced to a minimum. The vapor compressor and its low-pressure steam-turbine driver do not require an engineer in constant attendance; and the inherent characteristics of the type are such as to make it self-regulating to a large degree. Considerable variations in load affect the chilled-water temperature very slightly, so there is eliminated the otherwise imperative need of automatic control instruments.

Thirty Years of Canadian Mining

The Newer Gold Fields
Part 1

R. C. Rowe





SILVER ISLET MINE

One of the strangest of the world's mines was started in 1868 on a tiny rock near the Canadian shore of Lake Superior. In the face of the difficulties which this position imposed, there was developed a remarkably successful property that, in the end, yielded $3,000,000 in ore. To make this possible the islet was enlarged with cribbing filled in with rock from the mine. These views, taken prior to 1890, show two scenes on the island; homes of the miners on the lake shore; and a typical miner of those days.

I

THE discovery and development of the newer mining areas of western Ontario and northern Manitoba are directly traceable to the influence of such districts as Porcupine, Kirkland Lake, and northwestern Quebec. The results obtained there supplied the stimulus that sent men seeking far afield with visions in their minds and dreams in their hearts. The materialization of their visions and the fulfillment of their dreams constitute this chapter of the story we have been following; but back of the accomplishment of latter years lies a great deal of mining history which, though it has no proper place in this chronicle, forms a background that cannot be disregarded.

The mining history of western Ontario, like that of Quebec, is singularly interwoven with the past; and the region around Lake Superior was the scene of much activity long before the Canadian Pacific Railway was built. The first step in the chain of events we are tracing occurred in 1846, when 27 tracts of land running back from the Canadian shores of Lake Superior were granted to certain capitalists for exploration purposes. The applications covering these grants were based on a report by William Logan (later Sir William Logan) wherein he expressed the opinion that the area in question should be productive of mineral wealth. A later geologist, commenting upon the history of the area, observed that the operations resulting from these grants were more promotional than exploratory. However, some work was carried out during 1846-47 on two showings, one of which was on Spar Island and the other, known as Prince's Mine, was on the mainland. Both of these were silver veins, but were exploited as copper prospects. The copper deposits of the Bruce Mine, north of Lake Huron and east of Sault Ste. Marie, were also discovered in 1846. These were worked for many years, but were eventually closed down about 1875.

With the exception of copper mining there was very little to record for a number of years. Then, in 1866, Peter McKellar found the Thunder Bay Mine and started thereby a series of events that was to have reverberations far and near. The Thunder Bay Mine was located a short distance inland from Thunder Bay on Lake Superior. The property was a few miles northeast of Port Arthur. This discovery initiated a wave of prospecting; and in 1868 Thomas Mcfarlane located an extraordinarily rich vein, carrying native silver, on a small island that was really little more than a rock —having an area of only about 80 square feet—sticking above the waters of Lake Superior just off the promontory terminating in Thunder Cape. This afterwards became the famous Silver Islet Mine.

As we look back over these happenings we have to remember that they occurred long before the Canadian Pacific Railway had spanned Canada. In those days the Hudson Bay Company's post of Fort William was the headquarters of the mineral explorers. Then came the construction of the Dawson route to "the North West," at the lake terminus of which grew the Village of Prince Arthur's Landing, which eventually became Port Arthur. Gauged by time, these matters are very close; but, judged by events, they are far away because, in the interval, the Hudson Bay post and the little village have become busy lake ports through which pass the flood of grain from the vast western prairies which, in the meantime, have been developed into one of the greatest wheat-producing areas. It is when we view this panorama of events, when we look back upon mineral discoveries made only a matter of 70 years

NORTHERN TRAVEL

The dog sled was indispensable to the North before the airplane came. The factor of a Hudson Bay trading post is shown in his sleigh. The dog in the other picture is a real husky—half wolf. They are rare and valuable. The dogs used in the Red Lake rush were usually half-breed collies with a slight husky strain.

ago, that we get the impression of remote time.

In 1883 the Canadian Pacific Railway was completed from Winnipeg to Port Arthur, and the mineral district we have referred to was provided with transportation facilities rendering it easy of access. Previous to this, however, there were made a large number of discoveries, but most of these did little more than provide the basis for various promotions. Some, on the other hand, did become producers, and among these the Silver Islet was the most important. As we have already stated, the silver-bearing veins on this tiny islet were found in 1868.

Silver Islet was so small that in stormy weather the waves of Lake Superior broke over it, sweeping it clean of even the tiniest vestige of vegetation. It requires no stretch of the imagination to see that work under such conditions was extremely difficult; but, in spite of this, exploratory operations by the Montreal Mining Company in 1869 yielded 9,455 pounds of ore which was shipped to Montreal and netted $6,715.67.

In August of that year twelve men and a horse were detailed to sink a shaft on the islet. The foregoing is taken from an old report, and the rather naive lumping together of men and horse was perpetrated by its writer. We presume, though quite unenlightened, that the horse was intended for hoisting purposes; but the question immediately enters the mind: how could a horse work on what was merely a bare rock? However, as we read on, we find that the mining crew was instructed to take advantage of the protection afforded by the formation of ice around the islet, and to extract further ore.

We can easily understand that this operation, so concisely disposed of by the old chronicler, presented difficulties and hardships that were enough to stagger any ordinary man. Anyone who takes a minute to visualize being on an unprotected rock surrounded by ice and swept by the frost-laden gales of Lake Superior will appreciate what those twelve men and a horse went through during the winter of 1869-70. Remember, too, that those early miners were using hand steel; and those of this mechanical age that may have sat on a cold rock and twisted a drill will realize just what drill-twisting meant on that lonely and exposed rock.

In spite of this jaunt into the realm of fancy—which is fact, nevertheless—we are able to record that the efforts of "the twelve men and a horse" were quite successful, and that by spring the party had won 17,669 pounds of ore with an assay value of $18,291.39 (the odd cents are official). As these figures indicate ore running more than $1 a pound, or more than $2,000 a ton, it is evident that the Silver Islet vein was no ordinary affair; and, as a consequence, very serious work was concentrated upon it.

During the winter of 1870-71, the year of the Franco-Prussian War, breakwaters were constructed and the whole islet was inclosed in cribbing. What that hardy band of pioneers endured, even in the cold type of official reports, reads like fiction. Gales lashed Superior into waves that swept over the islet, demolishing the breakwaters and cribbing again and again; but the miners hung on and painstakingly rebuilt what Nature destroyed so ruthlessly. Eventually, rock-filled cribbing enlarged the area of the islet many times, a town grew on the rocky shore of the mainland, and a concentrating mill was constructed. Early in the story, the silver-bearing veins began to display erratic qualities. They changed in value and width in a most bewildering manner, and gave those in charge of the mine little peace of mind; but, in the end, Silver Islet produced more than $3,000,000 worth of the precious mineral.

It was at this mine that the Frue vanner was evolved by Captain Frue who was in charge of the property for a long time. The Frue vanner became known the world over as a concentrating machine; but the fact that it was born in Canada has been almost forgotten. Another interesting name that crosses the history of this old mine is that of R. Trethewey who, later, flashed into the early days of Cobalt.

Still later, in 1882 to be exact, remarkably rich silver veins were uncovered at Rabbit Mountain, and these resulted in a further burst of activity. During all those years there had been some discoveries of gold in the district, the first being at the Huronian Mine about 75 miles west of Port Arthur. Then, in 1891, came the Sultana Mine in the Lake of the Woods area. That strike was followed by a large number of others, among which might be mentioned the Mikado and the Regina, which were large producers in addition to the Sultana. The latter yielded gold to the value of about $1,000,000, and was the most important gold mine in Ontario previous to the finding of Porcupine.

These discoveries were the cause of a boom of no mean proportions, and the Town of Rat Portage (which, by the way, was later changed to Kenora, a name that is somewhat more euphonious even if less picturesque than Rat Portage) became a

FREIGHTING IN

These pictures show two Canadian Ingersoll-Rand steam-driven compressors and other equipment being taken into the Red Lake district. There was supposed to be snow, but it had melted in places, thus making transportation exceedingly difficult. To avoid such troubles, most heavy freighting to the mines is done in winter.

place of some fame. But the boom eventually collapsed, leaving in its train the usual welter of wrecked hopes and vanished dreams. The Lake of the Woods failure brings us nearly to the beginning of the period covered by this review—that dealing with Cobalt. It was so close that, according to no less a person than N. A. Timmins, it was partly responsible for the lukewarm reception given the Cobalt discoveries by the general public.

Be that as it may, the fact remains that developments in northeastern Ontario completely overshadowed the earlier ones around and adjacent to Lake Superior. In the light of mightier happenings, those older gold fields, and the country that lay north of them, sank into obscurity; but the drift of time and the tide of events were slowly but surely bringing influences into being that were destined to direct attention to the more westerly sections of Ontario.

II

THE first of the newer gold fields of Ontario to leap into prominence was Red Lake. This area lies about 180 miles northeast of Sioux Lookout on the Canadian National Railways; and while gold in any quantity was not found there until 1925, the district had received some attention a good man years before that; and once again we have to note that mingling of the past and present in the history of a producing field. In fact, while the Lake of the Woods area was working up to its hectic climax in 1893, Dr. D. B. Dowling of the Geological Survey of Canada spent a season exploring the Berens and Bloodvein rivers. During the course of this traverse he worked in the Red Lake Basin and published a report covering the rocks of the region. He also published a map which was the only one in existence for many years. His report and map constitute the first reference to Red Lake.

In 1897 a party of adventurous souls wandered into the district. It was made up of Englishmen who were completely lacking in bush lore, but who had the foresight to pick a Canadian, named R. J. Gilbert, to direct their activities and to act as leader. There is no doubt that the expedition was carried out for prospecting purposes, and was probably inspired by the developments at Lake of the Woods. The party worked around Slate Bay where some free gold was located on a ridge lying about a quarter of a mile inland from the lake. We can imagine that there was a lot of elation around the campfire as the little group made its plans to return to civilization in order to file its claims.

Those who know the loneliness of outlying places and the longings of men can easily visualize what dreams each member of the party fabricated in the dancing flames of the fire; but stark tragedy had already cast its shadow over them. On the return journey, Gilbert, the only experienced bushman, was accidentally shot. Crossing a portage, his revolver slipped from its holster and was fired by the impact of its fall. The bullet pierced his body, and he was killed almost instantly. As a consequence, his comrades were faced with a terrible problem.

Gilbert was a big man, the weather was hot, and the Red Lake trail was hard and long. The easiest way would have been to dig a shallow grave on that lonely portage and to go on; but to their everlasting credit the men did not take the easy way. They brought the body of their leader out over that long trail to civilization, a splendid act of loyalty. The claims of this ill-fated expedition were worked during the next year or two. Today, a shaft about 25 feet deep is mute evidence of this work; but the identity of those who did it seems to be lost.

There was no further activity until 1922, when a vein carrying silver-bearing galena was discovered. This created quite a stir, and the mild rush that ensued resulted in a lot of staking, most of which was of the blind variety. There were, however, some experienced prospectors in the district, and these recognized the great fact that the geological features were favorable to the occurrence of gold. A search for quartz veins followed, and some gold finds were recorded. These stakings caused the Ontario Department of Mines to divert Dr. E. L. Bruce from the English River to the Red Lake region, where he spent a part of 1922 and all of the 1923 season. His report was published in 1924, which brings us to the consideration of one of the most competent and colorful prospectors Canada has ever known. We are referring to the late Lorne Howey who, in addition to being a most practical person, was a close student of all literature relating to mineral areas.

Howey was typical of a class of men that had grown into being during the years of intense exploration in northern Ontario and Quebec. They were the new prospectors who combined bushcraft with a working knowledge of geology. These men eliminated, so far as possible, the old hit-and-miss methods of the past; and they are almost entirely responsible for the development of the newer gold fields referred to in this chapter.

TRENCHING

In most parts of Canada the uncovering of ore calls for plenty of hard work. The country is flat or rolling, and veins are hidden by a mantle of soil and a generous growth of trees and brush. At the left is a prospector in winter garb.

Lorne Howey read Doctor Bruce's report, and carefully assessed the potentialities of the district. The result of his cogitations was the formation of the Howey Red Lake Syndicate which was financed with Haileybury money. This syndicate was characteristic of the methods of the new type of prospector, who starts his ventures on a businesslike basis. Howey picked George McNeeley as his partner, and the pair took the Red Lake trail in the spring of 1925.

The fruits of that trip are evidenced today by the Town of Red Lake, the dull thud of underground blasting, and the roar of concentrating mills. During that summer Lorne Howey staked, on the shores of Red Lake, the mine that now bears his name, though he—as the Indians of the North so picturesquely term it—"has passed into the mist." Howey took the news of his discovery to his partners in Haileybury, and after some discussion it was decided to offer the proposition to John E. Hammell, who has figured in these pages in connection with Cobalt, Porcupine, and northwestern Quebec, and who had a very considerable hand in the birth and development of Flin Flon—Manitoba's great copper and zinc producer.

Once the decision was made, quick action followed, and Hammel was contacted by long-distance telephone. In that conversation two elements were involved—good salesmanship and the temperament of a man willing to take a chance. They evidently connected, because the result of that talk was a journey by Hammell to Red Lake. He took with him a man who had been mixed up with big things—no less a person than Alex Gillies who had accompanied Benny Hollinger on his epoch-making trip into the Porcupine district and who had staked four of the claims now included in the Hollinger Mine.

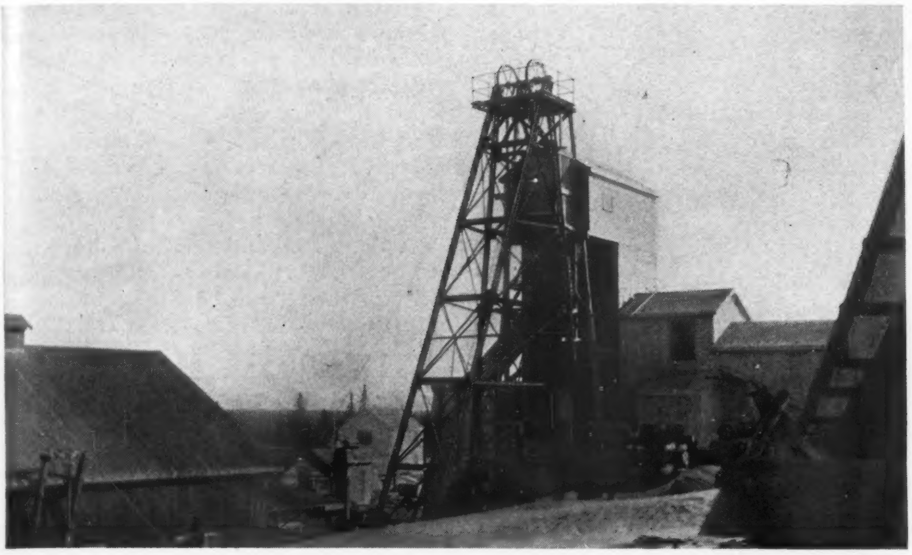
The author of this history has in his possession a personal communication from Hammell relating the experiences of that first journey to Red Lake. Space will not permit a detailed description of it; and we must dismiss it here with the remark that it was very full of incident and a good deal of hardship. Hammell and Gillies conducted separate examinations of the property, and did not compare notes until they had both looked it over thoroughly. During their investigations the surface showings were carefully sampled. Both men were enthusiastic about the showings; but, being old-timers, they tempered their enthusiasm with some reservations.

As soon as the sampling assays were in hand, Hammell hurried to Haileybury to interview the syndicate. He made an arrangement with it whereby he agreed to put up $50,000 for development in exchange for a half interest. When these negotiations were completed, he started to act with his usual speed and placed the property in charge of Alex Gillies. The season was getting late and he wished to get his equipment into the property, which lay 180 miles from the railway, before the freeze-up.

In the face of this problem, and in his fight against the seasons, he took the courageous step of calling to his aid the aeroplane. He prevailed upon the Ontario Government to lend him seven forestry machines to effect the movement of his men and supplies from Sioux Lookout to Red Lake. This seems a commonplace thing in these days; but even so short a time ago as ten years the use of aeroplanes for the wholesale transportation of equipment was almost without precedent in Canada—the only previous movement of the kind having been to Rouyn, and even in that case operations were confined to the carrying of ordinary freight rather than heavy machinery. However, the transfer was made without a hitch; and men, supplies, and equipment were landed at Red Lake before the freeze-up.

This movement of freight had some rather remarkable results, which should be noted here because they were to have a very important bearing on the mining history of Canada. The forestry air pilot in charge of the transportation of the Howey equipment was "Doc" Oakes; and the operation set him thinking very seriously about the possibilities of commercial aviation in opening up the North Country. As so often happens when men start to dream dreams of this sort, the idea fired his imagination, and he pictured planes touching lakes unknown to white men. He realized that the North, with its multitude of lakes and waterways, offered a unique opportunity for air travel, and the more he thought about it the more enthusiastic he became. Finally, he went to Winnipeg and saw James A. Richardson, whom he knew to be a man of extraordinary vision and great wealth. Richardson took up the idea, and thus Western Canada Airways was born.

Western Canada Airways was the fore-



DELIVERED BY PLANE

Headframe of the Pickle-Crow Mine, in the Red Lake district, the steel for which was flown in 180 miles from the nearest railroad. The boom at Red Lake was indirectly responsible for the development of what is now Canadian Airways, Ltd.

runner of Canadian Airways, Ltd. Both companies have played and are still playing a tremendous part in Canadian mining. Soon after its inception, Western Canada Airways provided bases at a number of outlying points and instituted air service to all new fields. It has been said that the two companies have advanced the development of Canada's newer mining areas at least twenty years; and anyone who is familiar with their work and that of their pilots in northern Ontario, northern Manitoba, and northern Quebec, not to mention British Columbia and Great Bear Lake, will admit the truth of this statement. There is no doubt that all that "Doc" Oakes envisaged in the autumn of 1925 has come to pass, and probably a great deal more than he dreamed about. Since those days the aeroplane has covered all that vast stretch of country lying north of the Canadian National Railways' transcontinental line clear up to the Arctic Circle and beyond.

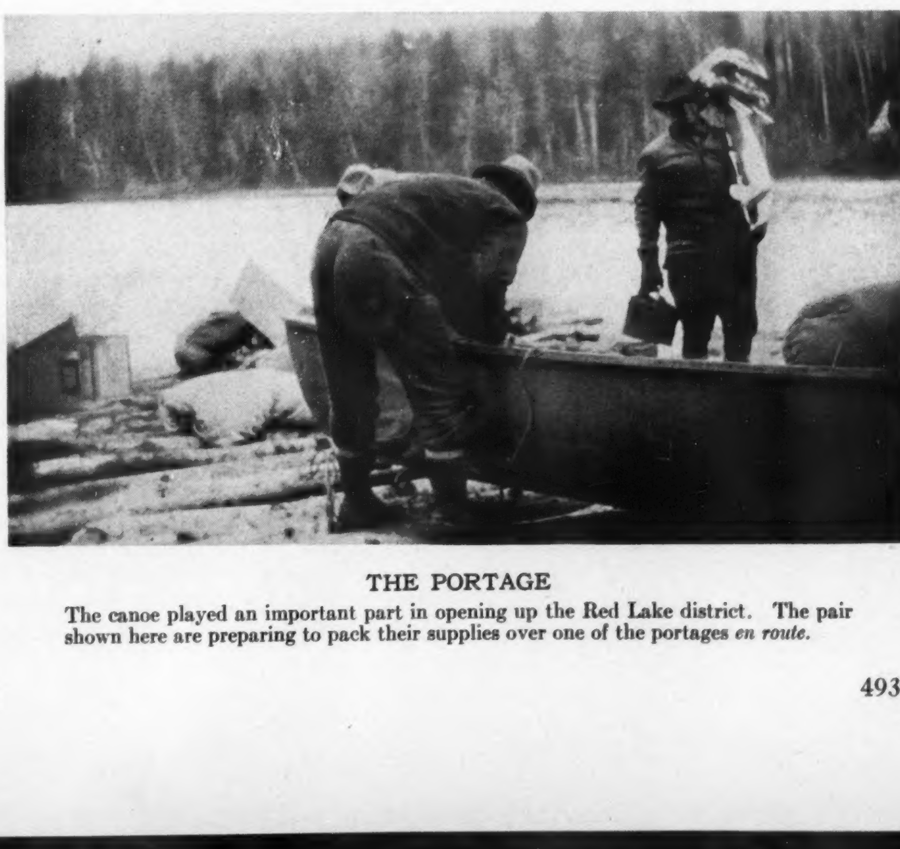
Returning to Red Lake, we find that activities at the Howey started a rather hectic gold rush, and by the spring of 1926 more than 3,500 claims had been staked. The whole district was in a fever of excitement, and the prediction was freely made that a second Porcupine was at hand. Optimism ran high, and there began the inevitable orgy of wildcatting that in the end retarded the general development of the field for some years. Meanwhile Dome Mines, Ltd., had taken an option on the Howey Mine. The terms of this option were high, being $500,000 in cash and an expenditure of $1,000,000 on the property in two years for a 75 per cent interest in the enterprise. A systematic diamond-drilling campaign was carried out; and after a while rumors began to circulate that results were not what they should be. The engineers in charge were reticent, as engineers always are. They neither denied nor confirmed the rumors; but in August of 1926 Dome Mines Ltd., dropped its option.

That was a sad blow for the camp in general and the Howey in particular. Interest began to wane, and Hammell found himself confronted with the monumental task of financing a property which had been turned down by a great mining company. It was a prospect that would have daunted most men; but Hammell, being just himself, went straight ahead. He personally bought back the stock that Dome had taken in consideration of work done to date, and, finally, by almost superhuman efforts, succeeded in arranging for the financing of the venture. Horace Young was appointed manager, and to him was entrusted the task of developing the Howey and of bringing it to production. When considering the task that faced him, it must be remembered that the property was 180 miles from the railway, which meant that the management also had to organize a transportation system. All this was done, and the mine was brought to production two years and nine months from the time the first round of holes for the shaft was fired.

The history of the Howey from that date to the present has not been an easy one. Into the accomplishment has gone an immense amount of effort, and courage of a high order. As the mine unfolded it became apparent that it was a low-grade, high-capacity, and low-cost proposition. These factors necessitated changes in policy, and the company ran into financial difficulties. At a critical period one of the shareholders, W. S. Cherry, loaned the company $600,000, which is a lot of money. This is an outstanding example of faith in a mining venture which, we are glad to be able to record, has been fully repaid. The Howey has become one of the lowest cost-per-ton gold mines in the world, and it has had the effect of changing our entire comprehension of the economics of gold mining. It has given the whole country the opportunity to revaluate its gold prospects, and it has also opened a new vista to prospectors in unexplored areas.

While the Howey Mine was engaged in making gold-mining history, the affairs of the district in general were not flourishing. The region had suffered from an orgy of wildcatting; and after it subsided, interest languished and at last became almost extinct. It was not revived until economic conditions forced up the price of gold.

Prospecting around Red Lake followed its usual trend, and spread out from the central discoveries to other likely districts in the vicinity. One of these was the Woman Lake and Narrow Lake area, which is almost directly east of Red Lake. There was considerable activity in this region during 1926, and among the numerous



THE PORTAGE

The canoe played an important part in opening up the Red Lake district. The pair shown here are preparing to pack their supplies over one of the portages *en route*.

HOWEY VEIN

The Howey Mine was discovered by Lorne Howey, one of the first of the new school of prospectors who combine bushcraft with a working knowledge of geology. It had many ups and downs before establishing itself as a producer. The picture shows one of the 22 trenches made to secure samples prior to the early optioning of the property.

claims staked was the Jackson Manion which has lately come into production after a somewhat checkered career.

As time went on, the movement from Red Lake continued to progress, and penetrated to Shabumeni and Birch lakes lying almost due north of Woman Lake. There, in 1929, J. A. Borthwick uncovered the Casey Summit Mine. East of this district is the Pickle Lake-Crow River area where are located the Central Patricia Mine and the Pickle-Crow Mine, both of which were found in 1928. The Central Patricia was acquired by F. M. Connell and associates, and a lot of work was carried out under the management of Walter Segsworth, with A. J. Keast—now manager of the Beattie Gold Mine—as superintendent. The property was closed down in 1930, but was reopened when gold prices began to rise. It eventually came into production in 1934. The Pickle-Crow was taken over by Northern Aerial Minerals Exploration, Ltd., usually known as N.A.M.E.

We may digress here to touch briefly upon a phase of prospecting as exemplified by Northern Aerial Minerals Exploration, Ltd. This company was the result of a full realization of the possibilities of the aeroplane in the development of the North. It was fathered by Hammell; and the underlying idea was the transportation of prospectors to outlying districts by plane. A brief consideration of the geographical features of northern Canada will show that it is a region of vast distances which, until the advent of the plane, could be traveled only by water routes in the summer. As water transportation in such a country is slow, and as the open season is short, the range of action of prospecting parties was definitely limited. Obviously, the plane changed all this. Men could reach in a few hours areas that it had previously taken them weeks to make. Furthermore, once they were in a district they wished to prospect, they were not completely cut off from the outside world for months with the specter of sickness and accident hanging over them, as planes from established bases could contact them at definite intervals.

Northern Aerial Minerals Exploration, Ltd., maintained its own planes and various main and sub-bases scattered throughout the North. Its flying operations were in charge of the same "Doc" Oakes who had helped to organize Western Canada Airways, Ltd., and its surface operations were supervised by the late E. Duncan who had been at Flin Flon. The company transported parties of prospectors, each under the leadership of an experienced man, into districts which were considered favorable to the occurrence of minerals. These parties were regularly visited by its planes, and a careful record of their movements was kept. This writer has vivid recollections of being in the head office of the company and examining a great map of northern Canada which occupied the best part of one side of the room. Here and there, throughout that great expanse of country, small flags were stuck, denoting the positions of groups of prospectors. They were in such places as the west and east shores of Hudson Bay, the Coppermine River, and northern British Columbia. While we were tracing some of their movements, a wireless message came through from Chesterfield Inlet asking whether an N.A.M.E. plane, then at Baker Lake at the extremity of Chesterfield Inlet, could be used by the Canadian Mounted Police to examine the dead body of an explorer reported by Indians as lying in an old trapper's cabin miles inland. Standing there in that office, high in a skyscraper in Toronto, it was brought home to us how close science and progress had brought those remote regions—so close that, as we stood there, the shadow of that wilderness tragedy and the silence of the barren lands fell across us, rendering us quiet and wordless with a sense of sadness.

In a few years N.A.M.E. covered all parts of the North, and carried out development work in many places, one being as far north as the Dismal Lakes in the Coppermine River district where the frost never leaves the ground and where diamond drilling on a copper deposit was actually done. During all its operations in far-away regions it had but one casualty—a man who was caught in one of those blinding blizzards that can sweep down on the barren lands with a ferocity that defies description. The whole venture was one of the greatest and most romantic prospecting efforts in the history of mining.

There were other exploration companies which used chartered planes for the same purpose, among them being Dominion Explorers, Ltd., and the Cyril Knight Prospecting Company. The former was a subsidiary of Ventures, Ltd., which has been mentioned previously, and the latter was founded by the same Cyril Knight who, as we know, was associated with the famous Doctor Miller in Cobalt. These several companies scoured northern Canada from the tip of Ungava to the northernmost of the Canadian Rockies. In their comings and goings there was high adventure and incident as varied as the colors of a kaleidoscope. They made the drone of aeroplane engines a familiar sound to the Eskimos, and, to paraphrase Kipling, "The lean white bear hath heard it in the long, long Arctic nights." The shadows of their wings were thrown on the blinding white of the ice floes of the farthest North, and their men tramped the flower-strewn vastness of the barren lands where the sky is like a great blue bowl and the sun hugs the flat horizon. All that those men did and all that they endured can have no place in this chronicle, for there is material enough in the telling of these things to fill a book. They are referred to briefly as an indication of the new prospecting that had come into being since the days of Cobalt, where this history began. They are a part of the evolution we have traced, and an evidence of the restlessness of human progress.

As we have already stated, the Pickle-Crow Mine was acquired by N. A. M. E., and was finally brought to production through the efforts of John E. Hammell. Meanwhile, the success of the Howey Mine and the rising price of gold had again riveted attention on Red Lake. After a period of slumber, the original district once more sprang into activity, with the result that another producer, The McKenzie Red Lake Mine, came into being, with prospects of others in the not distant future.

This is the ninth of a series of articles by Mr. Rowe. The tenth will appear in the February issue.

OUR FUTURE OIL SUPPLY

TALK of a petroleum shortage in the United States is again being heard. There was much of it back in 1912, but the development of the cracking process greatly increased the yield of gasoline from each barrel of crude and, as a result, the fears then expressed proved to be unfounded. Another, but a milder scare appeared during and following the war years; but the introduction of geophysical prospecting allayed it by bringing about the discovery of important new producing fields. In the light of these experiences, the general public is disinclined to attach much significance to the current predictions of an imminent shortage. Nevertheless, they are being put forward by well-informed men, and cannot be ignored. A pamphlet recently circulated by the Chemical Foundation reviews the situation in some detail.

Estimates given, place the known, recoverable petroleum reserves at from 10,000,000,000 to 13,000,000,000 barrels. It is stated, however, that, under present production methods, this oil cannot be obtained fast enough to keep pace with the demand. Accordingly, it is predicted that the days of shortage will begin within a relatively few years. A clear-cut distinction is made, though, between shortage and exhaustion; and it is conceded that the supply—assumed to be the quantity mentioned—will not be depleted for probably 50 years.

The evidence in support of the viewpoint held seems to be strong. It is pointed out, for example, that no field of national importance has been discovered for four years. This in spite of the fact that wells of 12,000 feet depth have penetrated the entire series of sedimentary rocks in several of the older producing states in the hope of developing deep horizons.

The crux of the situation is found in the record of dry holes drilled. In Texas, the percentage was well below 30 prior to 1919, in which year it was only 17, but since then it has risen to 45. In Oklahoma, the percentage ranged between 7 and 20 from 1904 to 1917; between 20 and 30 from 1918 to 1923; and between 30 and 35 from 1924 to 1933. In California, from 3 to 12 per cent of the holes were dry between 1905 and 1912; but between 1913 and 1930 the percentage rose to from 21 to 26, and for the three following years it was 49, 48, and 40, respectively. These figures carry added weight if it is remembered that the science of petroleum geology is much more advanced today than it was fifteen years ago, and that the number of geologists in the field is much greater. It should be remembered, too, that we import but little of our oil supply and that we can draw heavier upon other parts of the world as need arises.

Fortunately, we have vast stores of potential oil in the form of coal and oil shale. By the process of hydrogenation a satisfactory crude oil can be obtained from these materials, of which billions of tons in several states—notably in Colorado, Wyoming, and Utah—are awaiting treatment. But present costs of extracting their contained oil is too high to enable them to compete with petroleum secured from wells; and it is fairly well established that coal and oil shale will not be exploited until the price of oil rises.

Some alleviation of the shortage is promised by a wider application of hydrogenation to crude oils. The average yield of gasoline from a barrel of crude oil by cracking alone is 60 per cent: by hydrogenation it is 108 per cent. The growing demand for diesel engines is also considered to be a helpful factor.

To sum up: We will continue to use petroleum products; but they will in all likelihood be derived increasingly by means of chemical processes and decreasingly from wells. This change will be accompanied by a considerable rise in the cost of gasoline and of other refined products. The higher price of gasoline will, perhaps, bring about changes in the design of automobile engines emphasizing greater mileage per gallon and subordinating speed, thus following the trend in Europe where gasoline, largely because of taxation, now sells for up to 86 cents a gallon.

INDIANS AS COPPERSMITHS

NEW information that sheds important light upon the cultural attainments of the American Indians is being obtained at the Montana School of Mines from metallographic studies of relics taken from mounds in various parts of the country. Evidence is rapidly accumulating in support of the theory that the primitive Americans were fairly well advanced in the art of working copper. It is furthermore indicated that this knowledge extended to many tribes living in widely separated areas.

With the aid of the microscope, Dr. Curtis L. Wilson and Prof. Melville Sayre have determined that arrowheads, spearheads, awls, beads, and other objects were made from copper by hammering, and that in many instances they were afterwards heat treated to remove brittleness. Some of the results of the investigations thus far made have been published by Doctor Wilson and Professor Sayre in an article in *American Antiquity* for October, 1935.

Examination of copper articles unearthed in Wisconsin and Ohio has led to the conclusion that the copper, in certain cases, was heated to temperatures of 932° to 1,472°F. before being hammered, and that it was subsequently annealed to extract some of the hardness imparted by the pounding.

A surprising fact is that all the objects so far studied seem to have been made from copper obtained from the Lake Superior region, where it occurs in remarkably pure native form. This is true not only of the copper in the weapons and tools but also of that in beads that were unearthed in New Jersey and sent to the Montana school by the state museum at Trenton.

Scientists have been puzzled as to the purpose of some of the stone tools that have been found in Indian mounds; but now it would seem that they were used by the coppersmiths. With a view to adding to the fund of knowledge of Indian metalworking, it is requested that additional copper materials of Indian origin be sent to the Montana School of Mines at Butte.